

LIBRARY OF THE
DEPARTMENT OF
MINES
OTTAWA

CANADA
DEPARTMENT OF MINES
HON. LOUIS CORDERRE, MINISTER; R. G. MCCONNELL, DEPUTY MINISTER
MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR.

REPORT
ON
The Salt Deposits of Canada
AND
The Salt Industry

BY
L. Heber Cole, B.Sc.



OTTAWA
GOVERNMENT PRINTING BUREAU
1913

No. 325



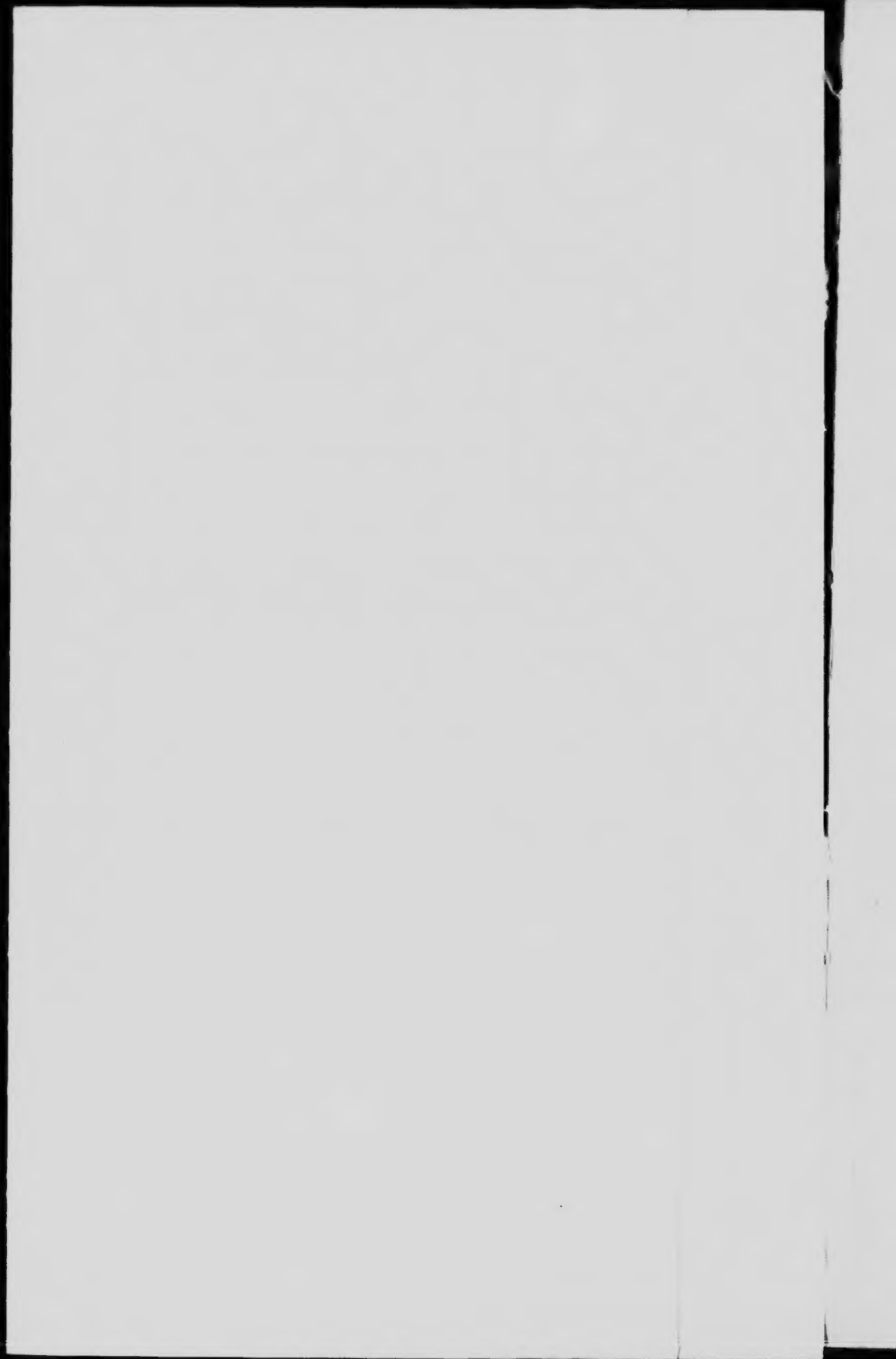


Saline Spring C, Winnipe

FRONTISPIECE.



C, Winnipegosis district, Manitoba.



CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. G. McCONNELL, DEPUTY MINISTER
MINES BRANCH
EUGENE HAANEL, PH.D., DIRECTOR.

REPORT
ON -
The Salt Deposits of Canada
AND
The Salt Industry

14750

BY
L. Heber Cole, B.Sc.



OTTAWA
GOVERNMENT PRINTING BUREAU
1915

No. 325

01025364

LETTER OF TRANSMITTAL.

To Dr. Eugene Haanel,
Director Mines Branch,
Department of Mines,
Ottawa.

Sir,—

I beg to transmit, herewith, a report on The Salt Deposits
of Canada, and the Salt Industry.

I have the honour to be, Sir,
Your obedient servant,

(Signed) L. H. Cole.

Ottawa, Nov. 14, 1914.



CONTENTS.

INTRODUCTORY.

PART I.

THE SALT DEPOSITS OF CANADA

CHAPTER I.	PAGE
Salt and Its Associated Minerals.	3
Halite: Sodium Chloride or Rock Salt—	3
Chemical composition.....	3
Physical properties.....	3
Crystallization.....	4
Blow-pipe analysis.....	4
Occurrence.....	4
Table of localities.....	5
Associated minerals.....	6
 CHAPTER II.	
Theories of the Origin of Salt.	9
Introduction.	9
1. Volcanic theory.....	9
2. Evaporation theories.....	10
(a) Ochsenius.....	10
(b) Walther.....	12
3. Dome Theory of Harris.....	13
4. Natural brines.....	14
 CHAPTER III.	
Salt Occurrences in Maritime Provinces and Quebec.	15
Nova Scotia.	15
Introduction.	15
Brine occurrences at:—	
Whycocomagh, Inverness Co.....	16
Antigonish, Antigonish Co.....	17
Springhill, Cumberland Co.....	17
Salt Springs, Pictou Co.....	18
Walton, Hants Co.....	18
Cheverie, Hants Co.....	18
New Brunswick.	18
Introduction.	18
Brine occurrences at:—	
Sussex, Kings Co.....	19
Salt Spring Brook, Kings Co.....	19
Tobique River, Victoria Co.....	20
Quebec.	20

CHAPTER IV.		PAGE
Salt in Ontario.....		21
Introduction.....		21
Study of well records.....		22
Geology of the salt district.....		28
Theories of origin of the salt beds and brines.....		29
History of the Salt Industry in Ontario.....		30
Operating plants:—		
The Ontario People's Salt and Soda Co.....		34
Gray, Young and Sparling Company, of Ontario, Ltd.....		35
Stapleton Salt Works.....		35
North American Chemical Co.....		36
Western Canada Flour Mills Co., Ltd.....		36
Exeter Salt Works Co.....		37
Parkhill Salt Co.....		37
The Elarton Salt Works Co., Ltd.....		37
Dominion Salt Co., Ltd.....		38
The Western Salt Co., Ltd.....		39
The Canadian Salt Co., Ltd (Windsor Plant).....		40
The Canadian Salt Co., Ltd. (Sandwich Branch).....		41
Canadian Alkali Co.....		47
Brine analyses.....		48

CHAPTER V.		
Salt in Manitoba.....		49
Introduction.....		49
Theories of the origin of the brines.....		49
Early history.....		51
Saline springs.....		53
Winnipegosis district.....		54
General description and topography of the district.....		54
Springs encountered by Mr. J. B. Tyrrell:—		
Salt Creek.....		55
Banks of Mossy river.....		55
Salt Point—south end Lake Winnipegosis.....		56
Pelican Bay—mouth of Pelican creek.....		56
Pelican Bay—west side.....		56
Salt Point—Saline creek.....		57
Mouth of Steeprock river.....		58
Banks of Shoal river.....		59
Mouth of Swan river.....		59
Springs visited by writer:—		
Saline Spring A.....		60
“ “ B.....		62
“ “ C.....		63
“ “ CC.....		65
“ “ D.....		66
“ “ E.....		67
“ “ F.....		67
“ “ G.....		68
“ “ H.....		69
“ “ I.....		70
“ “ J.....		71

	PAGE
Table of data referring to Winnipegosis Saline Springs.....	72
Table of Analyses.....	72
Westbourne district.....	73
Tom Smith Well (Well K).....	73
James McBride Well (Well L).....	74
Westbourne Saline Spring (M).....	74
Government Well, Neepawa, Well O.....	76
Winnipeg district.....	76
Resumé and conclusions.....	79
Table of rainfall, snowfall, and temperature.....	80
Prices of salt in Winnipeg.....	81

CHAPTER VI.

Salt Occurrences in Saskatchewan, Alberta, and Northwest Territories.	83
Introduction.....	83
Localities:—	
Northern Alberta Exploration Co.....	83
La Saline.....	85
Salt river—Slave river district.....	86
Tar Island—Peace river.....	88
Red Earth creek.....	88
On line of 5th Meridian.....	89
Nahanni Butte—Liard river.....	89
Great Bear river—Mackenzie Basin.....	89
Firebag river.....	89
Christina river.....	90
Cypress Hills—Saskatchewan.....	90
Wetaskiwin district.....	90

CHAPTER VII.

Salt in British Columbia.	91
Introduction.....	91
Localities:—	
Kwinitsa.....	91
Nanaimo, Vancouver Island and Admiralty Island.....	92
Chilcotin Valley.....	92
Maiden creek.....	92

PART II.

THE SALT INDUSTRY.

CHAPTER VIII.

Statistics of Canadian Salt Production.....	93
--	----

CHAPTER IX.

Technology of Salt Manufacture.....	101
Introduction.....	101
Recovery of salt.....	103
(1) Natural brines.....	103
(a) Sea water.....	103
(b) Brine springs (weak and strong).....	103

	PAGE
(2) Rock salt	104
(a) Mined or quarried	104
(b) Artificial brines	104
Concentration of weak brines	105
(1) Solar concentration	106
(2) Wind concentration	106
(3) Freezing concentration	107
Evaporation methods	108
Introduction	108
Natural or solar evaporation	108
Solar salt aprons	112
Artificial evaporation	114
Direct fire evaporation	114
(a) Kettle process	114
(b) Pan process	114
Steam evaporation	116
(a) Kettle or pan with steam jacket	116
(b) Grainer process	116
(c) Vacuum pan evaporation	117
Early history	117
Principle of the vacuum pan	117
Multiple effect evaporation	118
Construction	118
1. Evaporating and condensing chamber	118
2. Heating element	118
3. Cone bottom	119
4. Filter or Barometric Leg	119
Operation	119
Swenson evaporator	120
Mantius evaporator	122
Brecht evaporator	124
Pick evaporator	127
Sanborn evaporator	127
Preparation of salt for the market	129
Special uses of salt	130

CHAPTER X.

The Allied Industries	131
Introduction	131
Sodium carbonate (soda-ash)	131
(1) Solvay process	132
(2) Electrolytic process	133
Sodium sulphate (salt cake)	134
Hydrochloric acid	135
Sodium hydrate	135
Electrolytic process	135
Chlorine	137
Bleaching powder	137

TABLES.

I. Distribution of Rock Salt and Brines	5
II. Thickness of beds, etc., Ontario salt basin	26
III. Table of Analyses of Ontario Brines	48
IV. Data of Brine Springs, Winnipegosis District, Man.	72
V. Analyses of Brine Springs, Winnipegosis District, Man.	72
VI. Rainfall and Snowfall Tables, Swan River, Man.	80

	PAGE
VII. Rainfall and Snowfall Tables, Dauphin, Man	80
VIII. Mean Temperature Tables, Swan River, Man	80
IX. Mean Temperature Tables, Dauphin, Man	80
X. Prices of Salt Products in Winnipeg, Man., and Fort William Ont.	81
XI. Production of Salt in Foreign Countries	94
XII. Detailed Statistics of Canadian Salt Production, 1908-1913 ..	95
XIII. Annual Production, 1886-1913	95
XIV. Imports of Soda Products into Canada	96
XV. Canadian Exports of Salt	98
XVI. Canadian Imports of Salt, paying duty	98
XVII. Canadian Imports of Salt, not paying duty	99
XVIII. Consumption of Salt in Canada, 1912-1913	99
XIX. Data of Brecht's Salting Evaporator	126

APPENDICES.

BIBLIOGRAPHY.

Appendix	I. Canada and United States: references arranged ac- cording to Provinces and States	141
"	II. World-wide references	144
"	III. Authors: arranged alphabetically	146
Index		153
List of Mines Branch Publications		

ILLUSTRATIONS.

Photographs.

Frontispiece.			
Plate	I.	A.	Saline Spring C, Winnipegosis district, Manitoba Plant of North American Chemical Co., Goderich, Ont
		B.	Settling tanks, Stapleton Salt Works, Clinton, Ont
"	II.	A.	Shipping wharf, Ontario People's Salt and Soda Co., Kincardine, Ont.
		B.	Ontario People's Salt and Soda Co. plant, showing railway facilities, Kincardine, Ont.
"	III.	A.	Packing shed, Ontario People's Salt and Soda Co., Kincardine, Ont.
		B.	Plant of Dominion Salt Co., Sarnia, Ont
"	IV.		Plant of Canadian Salt Co., Windsor, Ont.
"	V.	A.	Power house, Canadian Salt Co., Windsor, Ont.
		B.	Boiler room, Canadian Salt Co., Windsor, Ont. (Boilers fired by natural gas.)
"	VI.	A.	Drying bins, Stapleton Salt Works, Clinton, Ont. ..
		B.	Vacuum pans, Canadian Salt Co., Windsor, Ont. ..
"	VII.	A.	Drying bins, Canadian Salt Co., Windsor, Ont.
		B.	Packing room for coarse salt, Canadian Salt Co., Windsor, Ont.
"	VIII.	A.	Automatic bagging machine and bag sewer, Cana- dian Salt Co., Windsor, Ont.
		B.	Automatic bagging machines, Canadian Salt Co., Windsor, Ont

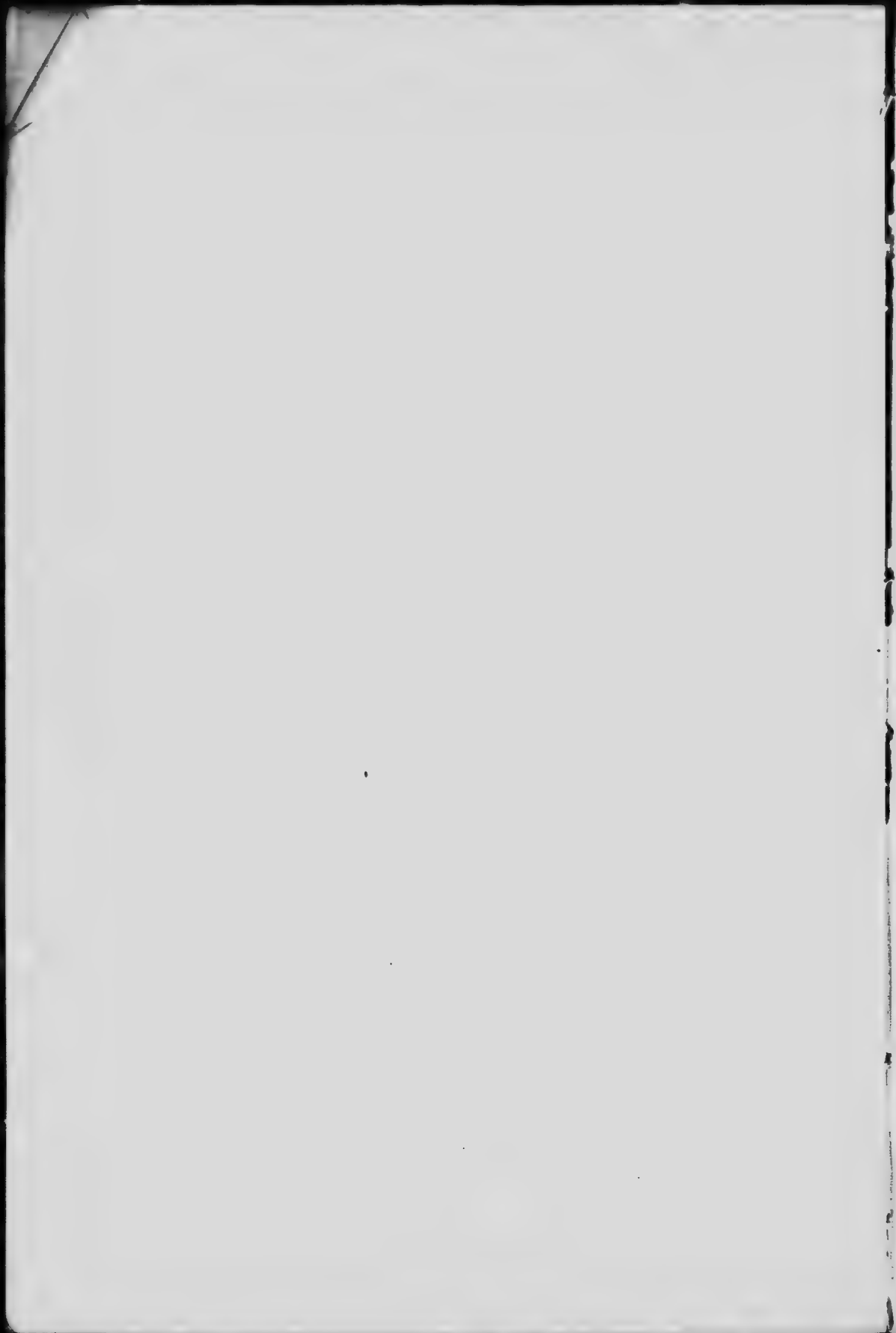
			PAGE
Plate	IX.	Plant of Canadian Salt Co., (Chemical Branch) Sandwich, Ont.	42
"	X.	A. Bleaching chambers building (in course of construction), Canadian Salt Co., Chemical Branch, Sandwich, Ont.	42
		B. Bleaching chambers building (in operation), Canadian Salt Co., Chemical Branch, Sandwich, Ont.	42
"	XI.	Salt flats, Saline Spring A, Winnipegosis district, Manitoba.	62
"	XII.	Salt flats, Saline Spring B, Winnipegosis district, Manitoba.	62
"	XIII.	A. Typical saline spring, Saline Spring B., Winnipegosis district, Manitoba.	62
		B. Typical saline pond, Saline Spring B., Winnipegosis district, Manitoba.	62
"	XIV.	A. Saline stream from Saline Spring F., Red Deer river, Winnipegosis district, Manitoba.	68
		B. Saline Spring F., Red Deer river, Winnipegosis district, Manitoba.	68
"	XV.	Saline Spring G., Red Deer river, Winnipegosis district, Manitoba.	68
"	XVI.	A. Saline Pond M., Westbourne district, Westbourne, Manitoba.	74
		B. General view of La Saline flats, looking northeast, Alberta.	74
"	XVII.	A. View of La Saline flats, looking north, Alberta.	86
		B. View of Devonian escarpment, near southeast corner of La Saline, showing incrustations of various salts.	86
"	XVIII.	Covers, Salina Salt Co., Syracuse, New York.	112
"	XIX.	Gathering solar salt, Salina Salt Co.'s yard, near Syracuse, New York.	112
"	XX.	Loading solar salt on to cars for shipment to plant, Inland Crystal Salt Co., Saltair, shore of Great Salt lake, near Salt Lake City, Utah.	112
"	XXI.	Ploughing salt in harvesting pond, Inland Crystal Salt Co., Saltair, shore of Great Salt lake, near Salt Lake City, Utah.	112
"	XXII.	Loading solar salt at the Oliver Salt Co.'s plant, Mt. Eden, California.	112
"	XXIII.	Showing one method of lifting salt from ponds, California Salt Co., Alvarado, California.	112
"	XXIV.	View of crystallizing pond, showing one field ready to harvest, Leslie Salt Co., San Mateo, California.	112
"	XXV.	Panoramic view, showing solar salt fields after stacking salt, Long Beach Salt Co., Long Beach, California.	112
"	XXVI.	Swenson triple effect evaporator in course of erection, United States.	120

Drawings.

	PAGE
Fig. 1. Salt crystal (after Dana)	4
" 2. Flow sheet, Dominion Salt Co.'s plant, Sarnia, Ont	38
" 3. Flow sheet, Western Salt Co.'s plant, Mooretown, Ont	39
" 4. Flow sheet, Canadian Salt Co.'s plant, Windsor, Ont	40
" 5. Flow sheet, Canadian Salt Co.'s plant, chemical branch, Sandwich, Ont.....	42
" 6. Gibb electrolytic cell.....	44
" 7. Sketch map, Saline Spring A.....	60
" 8. " " " " B.....	62
" 9. " " " " C and CC.....	64
" 10. " " " " D.....	66
" 11. " " " " E.....	68
" 12. " " " " F.....	68
" 13. " " " " G.....	68
" 14. " " " " H.....	70
" 15. " " " " I.....	72
" 16. " " " " J.....	72
" 17. " " " " M.....	76
" 18. Logs of wells sunk by the Northern Alberta Exploration Company, McMurray, Alberta.....	84
" 19. Sketch map, La Saline lake, Athabaska river, Alberta.....	86
" 20. Flow sheet showing method of salt recovery.....	102
" 21. Swenson triple effect evaporator.....	121
" 22. Mantius evaporator.....	122
" 23. Brecht evaporator.....	124
" 24. Pick triple effect evaporator.....	126
" 25. General assembly Sanborn double effect evaporator	128

Maps.

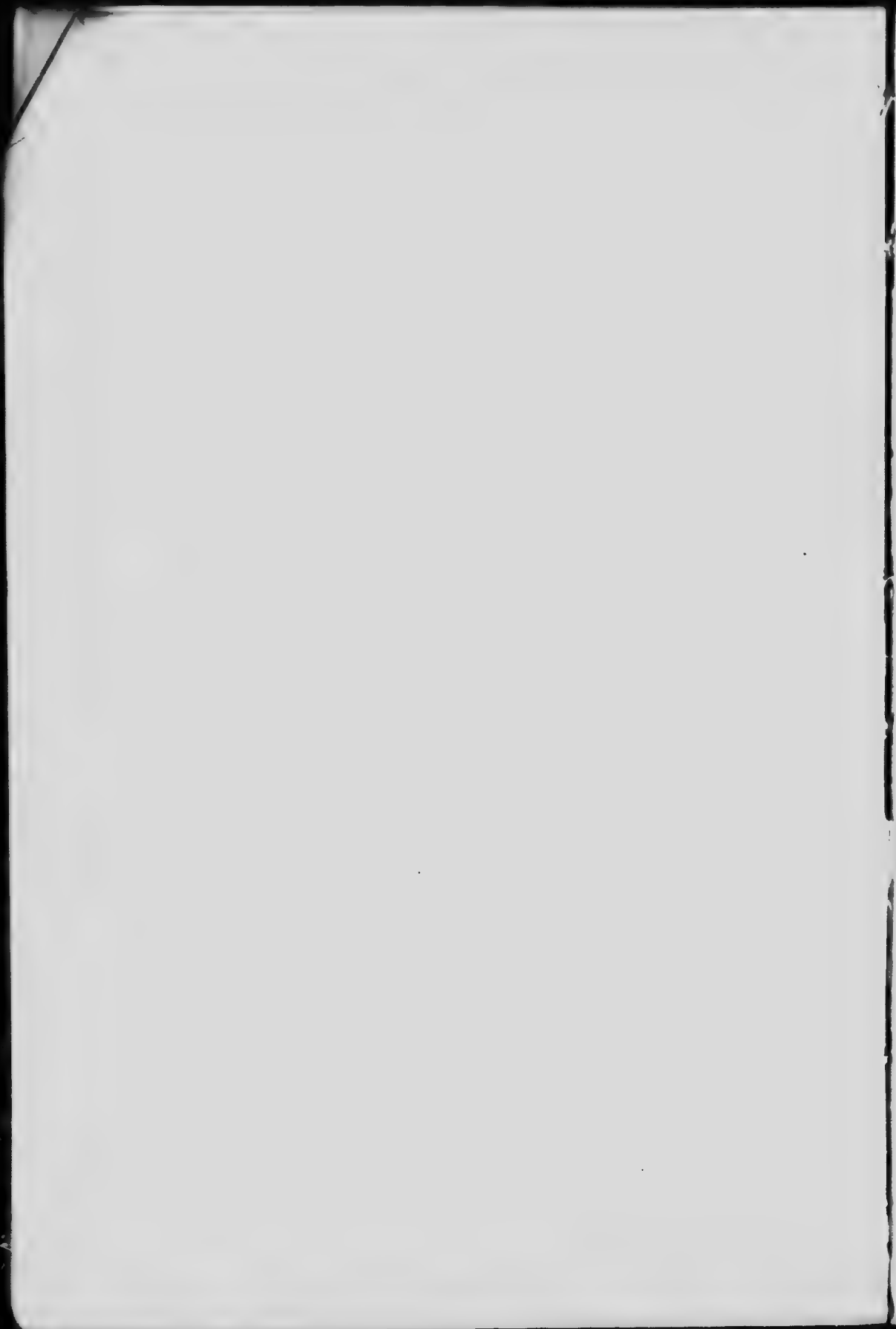
No. 327. Saline Springs and Salt Areas in Dominion of Canada.....	1
" 328. Saline Springs in Maritime Provinces.....	15
" 329. The Michigan-Ontario Salt Basin.....	21
" 330. Saline Springs in Northern Manitoba.....	49

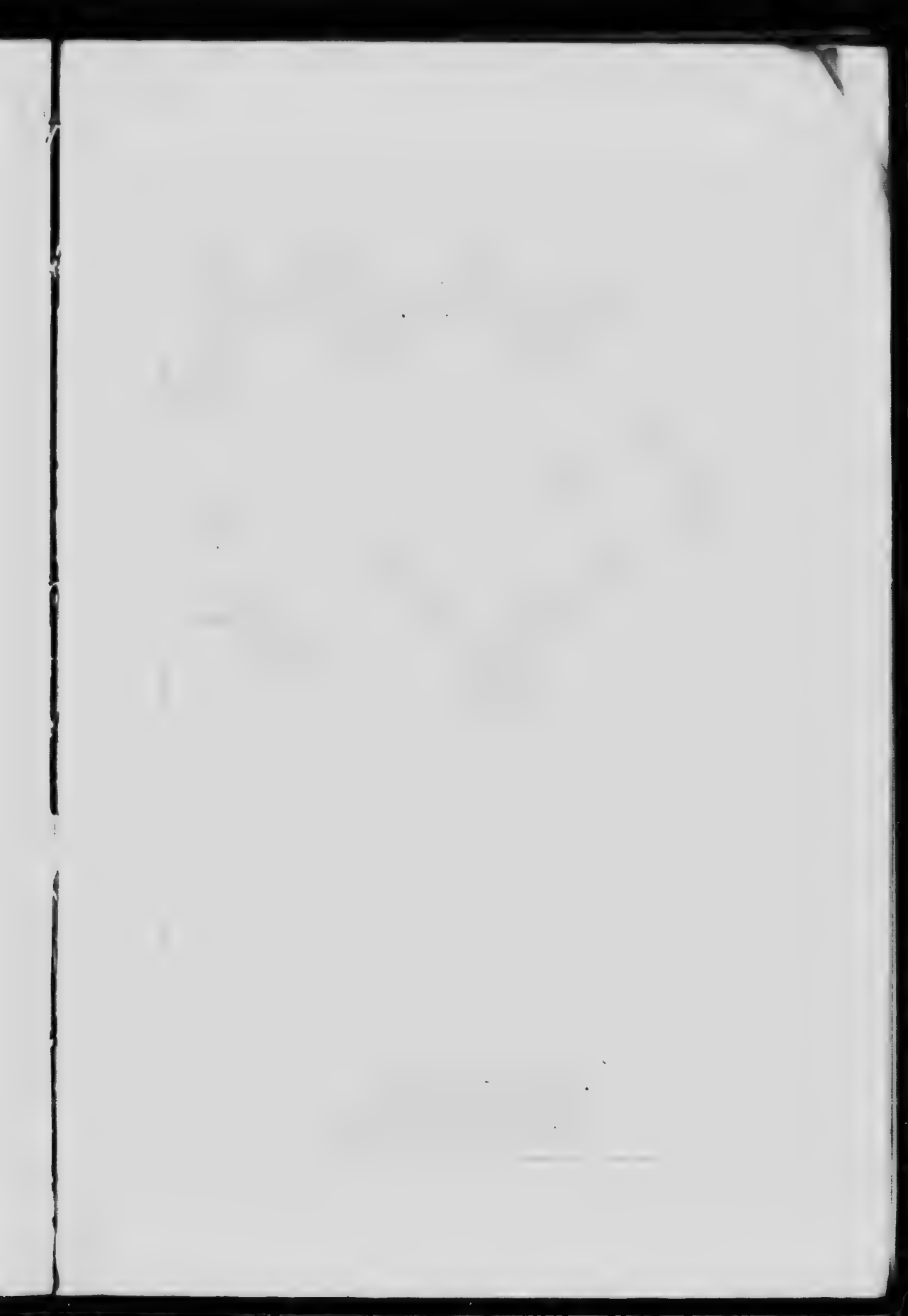


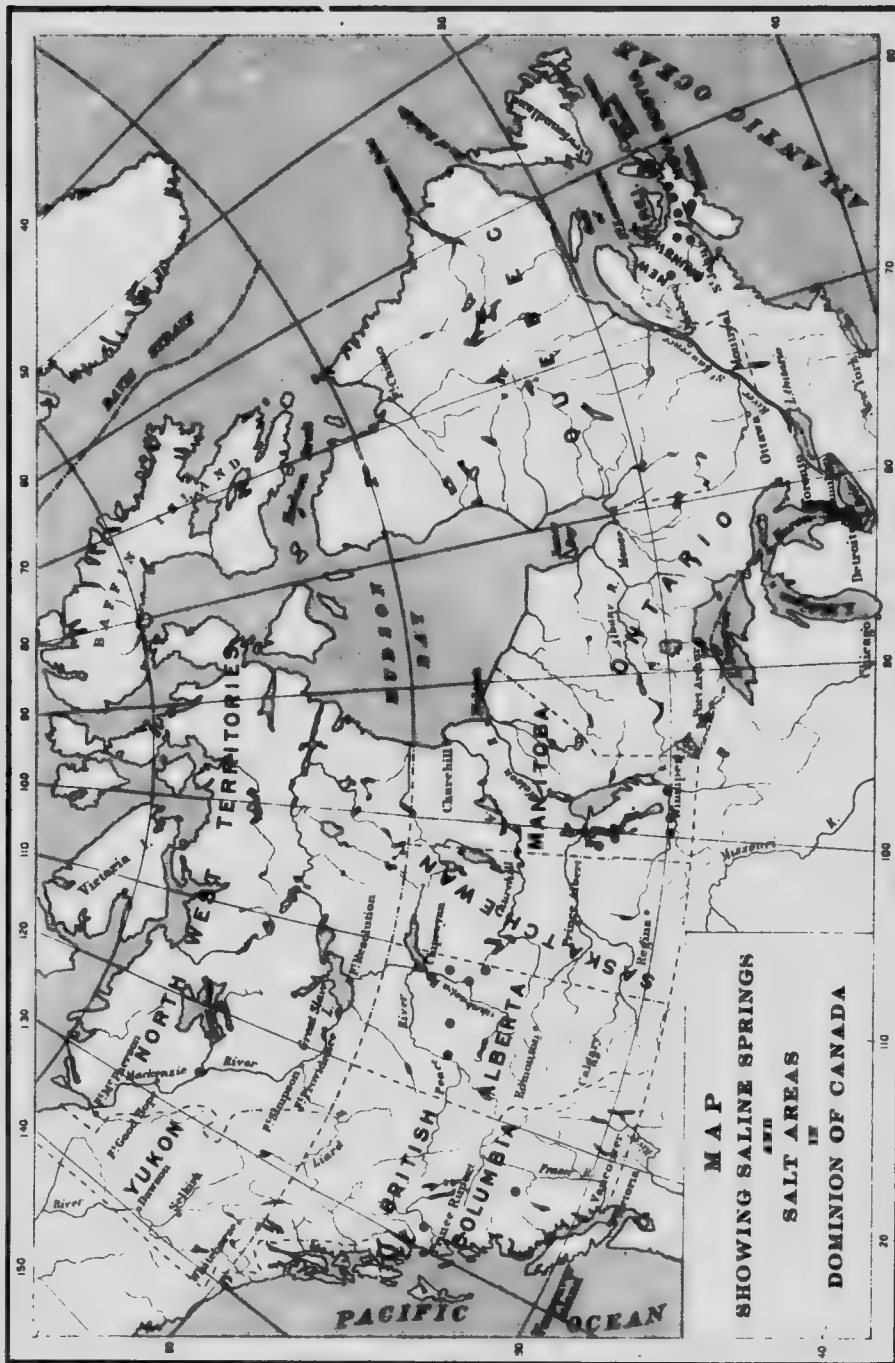
**THE SALT DEPOSITS OF CANADA
AND
THE SALT INDUSTRY.**

PART I.

The Salt Deposits of Canada.







THE SALT DEPOSITS OF CANADA AND THE SALT INDUSTRY.

INTRODUCTORY.

Salt is not only in universal demand for domestic purposes, but is used very extensively in a number of manufacturing industries.

In Canada, the salt industry has, hitherto, been of very limited extent, the amount produced in 1914, being only 107,038 tons, whereas the United States, in 1913, produced 4,815,902 tons. The future possibilities, however, of a forward movement in this industry are manifest when we glance at certain pertinent facts. The most obvious is, the rapid increase in the population of our inland cities, with a corresponding increase in the demand for domestic supplies of salt; and to this may be added the increasing commercial supplies needed to keep pace with the industrial growth of the country. At the present time, the sea-board provinces may obtain a cheap supply of imported salt; but the provinces far removed from the advantages of near-by ocean shipping must depend on local sources of supply.

The only salt deposits in Canada being exploited at the present time are those located in Ontario; hence this province is at a great advantage economically. On the other hand, the western provinces being minus any salt industries, are obviously at a great disadvantage, since they have to pay high freight rates on the whole of their supply. But saline deposits are known to exist in northern Manitoba, and in the Mackenzie basin, Alberta; and as quickly as these districts are opened up by means of railways, and systematic prospecting is carried on, other deposits will, no doubt, be exploited. This new industry will furnish a cheap supply to meet the western demand. It is manifest, therefore, that there are great possibilities of extending the salt industry in the western provinces.

Co-extensive with the rapid increase in the population of Canada—due to immigration—has been the establishment of new manufacturing industries for the utilization of the natural resources of the country. The salt industry has, naturally, been influenced by this growth, and, as intimated above, plants have already been established in certain parts of the Dominion to utilize the large deposits of sodium chloride, as a base from which to produce other commercial chemicals. Past enterprise in this direction has only touched the fringe of the available resources. The chances of profitable exploitation and investment along this line of industry are worthy of serious consideration.

Acknowledgments.

The writer, takes this opportunity of formally expressing his gratitude to the officials of the various industrial corporations with whom he came in contact while collecting data and information for this report, for the courteous treatment received, and for the generous assistance rendered.

PART I.
THE SALT DEPOSITS OF CANADA.

CHAPTER I.

SALT AND ITS ASSOCIATED MINERALS.

HALITE: SODIUM CHLORIDE OR ROCK SALT

Chemical Composition.

Halite: Common salt or rock salt, is composed of chlorine and sodium in certain proportions, and is represented by the formula NaCl.

100% sodium chloride (NaCl) = sodium.. (Na) 60.6 % + chlorine (Cl) 39.4%.

Sodium chloride is very seldom found pure in nature, being commonly mixed with small quantities of calcium sulphate, calcium chloride, magnesium chloride and, occasionally, with sodium sulphate, magnesium bromide, or iodide, and magnesium sulphate.

Physical Properties.

It has a hardness, according to Moh's scale of hardness, of 2.5, and a specific gravity of 2.1 to 2.6—pure crystals 2.135. Its lustre is vitreous. It is generally colourless, or white, sometimes yellowish, reddish, bluish, or purplish.¹ When found in the crystalline form it is transparent to translucent. It is one of the minerals readily soluble in water, and imparts to the solution a decided—or what is commonly known as—a saline taste.

¹Dana's Mineralogy, 6th Edition, 1906, p. 154.

Crystallization.

It crystallizes in the cubic system; the most characteristic form being the cube. These crystal forms are often distorted, or with hopper shaped faces. (See Fig. 1). The cleavage is cubic and the fracture conchoidal.

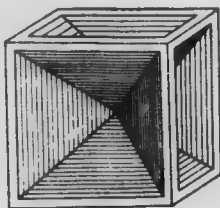


Fig. 1. Salt Crystal (after Dana.)

Blow-pipe Analysis.

A very characteristic re-action when fused on a platinum wire is the brilliant yellow colour (sodium flame) given to the blow-pipe flame.

Occurrence.

It is often found in the massive form; or in granular, compact aggregates, commonly known as rock salt.

In nature, common salt occurs also in the form of brines, which are more or less saturated solutions of rock salt in water, also in the waters of the ocean.

Beds of rock salt, and brines, are common in nearly every country in the world. The localities in which the mineral occurs are too numerous to mention in detail, the largest producing countries being the United States, United Kingdom, Germany, Russia, India, France, Spain, Japan, Italy, Hungary, Canada, Greece, and Algeria.

The following table of the distribution of rock salt and brines is taken from many reliable sources, among which might

be mentioned: Dana's Mineralogy; Geikie's Geology; Rock Salt, by Harris, and many others:—

TABLE I.
Distribution of Rock Salt and Brines.

Geological Formation	Localities.	
	Brine.	Rock Salt.
Recent	California (sea water); Utah; Arabia; South American States (sea water); shores of Dead Sea; Algeria; Mexico (sea water); Portugal (sea water).	Utah; Nevada; New Mexico; Kirghiz steppes; Arabia; Chili; Columbia.
Tertiary	Armenia; State of Tamilipar, Mexico; Java, East Indies.	Louisiana; California; Cordona, Spain; Wieliczka & Bochnia, Austria; Hungary; Siebenbürgen; Asia Minor; Armenia; Lungro, Italy; Roumania; Volterra, Italy; Kalusz, Galicia; Transylvania; Caucasus Mts; Salt Range, India; (?) Persia.
Cretaceous	Westphalia; Algeria; Kansas; Texas; State of Puebla, Mexico; State of Coahuila, Mexico.	
Jurassic		Rodenburg on the Deister; Bex, Switzerland; Cerro de Pasco-Peru.
Triassic	(Upper	Worcester, England; Cheshire, England.
	Middle	Nancy, France; Halle, Berchtesgaden, Hallein, Aussee, Tyrol; Cheshire, England; Antrim, Ireland; Isle of Man.
	Lower	Wurtemberg; Thuringia, Ernssthal, Stottenrheim; Canton of Aargau, Switzerland. Schoningen, near Brunswick, Salzderhelden.

TABLE I.—*Continued.*

Geological Formation.	Localities.	
	Brine.	Rock Salt.
Permian	Russian salines.	Stassfurt, Germany; Texas; Oklahoma; Hanover; Heilbronn.
Carboniferous	Nova Scotia, New Brunswick, Canada; Michigan; Ohio; West Virginia; Texas; Pennsylvania; Nebraska, U.S.A.	Durham and Bristol, England; Kansas; Texas; Virginia; Oklahoma.
Devonian	New York (Ordovician to Devonian); Alberta, Canada (?); Manitoba, Canada (?); Yeneseisk, Siberia; and Irkutsk, Siberia.	
Silurian	Manitoba, Canada (?); Sz-chuan, China (?).	Ontario, Canada; Michigan; New York; Ohio, U.S.A.

Note. The sign (?) after a locality means that the age of the deposit is not definitely determined.

Associated with sodium chloride in nature, both in brines and rock form, are a number of other salts. Of these, by far the commonest are the carbonates of lime and magnesia in the form of limestone-dolomites and marls; the sulphates of lime, magnesia and soda, and the chlorides of potassium and magnesium. These are seldom found in the same deposit, although in the Stassfurt deposits of Germany some thirty or more different minerals have been recognized in the same deposit. The following list by Harris¹, after Precht, gives the more important minerals found in these deposits:—

Primary Group.

Rock Salt.....NaCl
 Anhydrite.....CaSO₄
 Polyhalite.....2CaSO₄ + MgSO₄ + K₂SO₄ + 2H₂O
 Kieserite.....MgSO₄ + H₂O
 Carnallite.....KCl + MgCl₂ + 6H₂O
 Boracite.....Mg₇B₁₀O₂₀Cl₃
 Douglasite.....2KCl + FeCl₂ + 2H₂O

¹Rock Salt in State of Louisiana, by Harris: Bull. No. 7, Rept. of 1907, Geol. Survey of Louisiana.

Secondary Group.

Kainite.....	$K_2SO_4 + MgSO_4 + MgCl_2 + 6H_2O$
Sylvite.....	KCl
Schoenite.....	$K_2SO_4 + MgSO_4 + 6H_2O$
Langbeinite.....	$K_2SO_4 + 2MgSO_4$
Reichardite.....	$MgSO_4 + 7H_2O$
Jarosite.....	$K_2SO_4 + Fe_2SO_4O_{11} \cdot 2(Fe_2(OH)_6)$
Krugite.....	$K_2SO_4 + MgSO_4 + 44CaSO_4 + 2H_2O$
Glauberite.....	$Na_2SO_4 + CaSO_4$
Astrachanite.....	$Na_2SO_4 + MgSO_4 + 4H_2O$
Glaserite.....	K_2SO_4
Bischoffite.....	$MgCl_2 + 6H_2O$
Tachyhydrite.....	$CaCl_2 + 2MgCl_2 + 12H_2O$
Pinnoite.....	$MgB_3O_6 + 3H_2O$
Ascharite.....	$3MgB_3O_6 + 2H_2O$
Heintzite.....	$KMgH_2B_{11}O_{30} + 6H_2O$
Kaliborite.....	$Mg_2KH_2B_{11}O_{30} + 6H_2O$
Magnesite.....	$MgCO_3$
Iron Pyrite.....	FeS_2
Sulphur.....	S

Of these minerals, only four are being used commercially, to any great extent. These are carnallite, kainite, kieserite, and rock salt.

CHAPTER II.

THEORIES OF THE ORIGIN OF SALT.

Sodium Chloride, popularly known as "common salt," is one of the most widely distributed minerals in nature. It often occurs in bedded deposits interstratified with other rocks, or in other forms, and in such quantities as to be of great economic importance.

The origin of these salt deposits has long been of academic interest, and many theories have been propounded to account for the different forms in which they occur. Of the theories so far advanced, by far the larger number have failed to stand the test of increasing technical knowledge. The views which at the present time appear to be the most widely accepted, can readily be divided into four classes; (1) Volcanic theory; (2) Evaporation theory; (3) Dome theory of Harris; and (4) Natural brines.

(1) Volcanic Theory.

Volcanism, or volcanic action—the phenomena connected with the ascension of heated materials from the earth's interior, to its surface—has been made use of in numerous cases to explain the origin of many mineral deposits. It was early applied to explain the origin of salt deposits; especially since hydrochloric acid and sodium chloride were proved to be present in the emanations from volcanoes. According to Hubbard¹ the following classification will cover all the theories of the origin of salt which have volcanism as their fundamental principle:—

That "dolomite, salt, and gypsum, were brought up from the inner parts of the earth, either

(a) as molten masses, accompanied by great heat and development of gases, and with or without a display of violence, just like our basalts, porphyries and other volcanic rocks; or

(b) they were formed by the action of gases, either by sublimation or by the alteration of bodies already in place, or;

(c) they were formed in concentrated solution in hollows down in the earth's crust, and either solidified there after the manner of granite, or were

¹Geol. Surv. Mich., Vol. V, Pt. 2, p. XII, 1881-93.

exuded to the surface through cracks and fissures, after the manner of porphyries; or

(d) they (gypsum, and salt) were ejected with violence in the form of slime—a phenomenon familiar to us in mud volcanoes."

Of late years, however, these volcanic theories of the origin of salt have been gradually replaced by the broader theories known by the name of Evaporation Theories. It is now commonly accepted that, with the exception, perhaps, of accounting for the presence of salt around the fumaroles of volcanoes—which occurrences have never been of any economic importance—the volcanic theories have been practically abandoned.

(2) Evaporation Theories.

The theory that salt deposits are the result of deposition from sea waters, in basins connected with the ocean, was first advanced about the middle of last century. This theory, commonly called the Bar Theory, when first put forward by G. Bischof, was received with considerable opposition. During recent years, however, this theory has been studied by Dr. C. Ochsenius, who has reconstructed it, with important additions, which have overcome the most serious of the objections formerly made against it. The theory as given by Ochsenius may be briefly stated as follows: Imagine an inland sea, the entrance to which from the ocean is partially closed by a sand bar or barrier. The depth at this entrance being a great deal less than either the bay or the ocean, the bar forms a partial barrier between the two bodies. If then this bar is of sufficient height to allow only sufficient sea-water to enter the bay from the ocean, to balance the amount lost in the bay due to surface evaporation, it can readily be imagined that the deposition of some of the salts held in solution would soon take place. Under the conditions above stated, the evaporation in the bay going on rapidly, the upper layers of water become heavier, and sink. Thus, as the evaporation is continuous, the concentration increases with depth, until a sufficient concentration is reached to deposit the various salts. According to Usiglio¹, who carried on laboratory

¹For a reference to this work of Usiglio, see Geol. Surv., Mich., Vol. V, Pt. 2, p. XIII: Hubbard.

experiments on the evaporation of sea water, small quantities of carbonate of lime (CaCO_3) and of hydrous oxide of iron are deposited first; then 83.82% of all its sulphate of lime (CaSO_4); then 54.17% of all its rock salt (NaCl), at the same time that 16.18%,¹ the balance of its CaSO_4 , was being precipitated; then 8.5% of its salt (NaCl) without any admixture of CaSO_4 . The remainder of its NaCl —together with the more soluble salts of magnesia, potash, bromine, and iodine, which compose the bitters,—being finally crystallized in various combinations.

The "bar" entrance to this bay, however, is permitting more sea water to enter all the time, thus furnishing new supplies of salts to be deposited, as well as diluting the waters of the bay. If, then, this influx were regulated in such a manner as to maintain constantly the water of the enclosed bay at such a density that the sodium chloride would be deposited, and the more soluble salts kept in solution, it can readily be imagined that a bed of salt would be formed, and keep on forming, as long as the bar and other factors remained the same.

It can readily be seen, therefore, that in order to account for thick deposits of salt by this theory, the continuous connexion of the bay with the ocean is required, and the influx must remain constant. But if the bar changes, and if it is composed of sand, it is very liable to do so, the salts deposited in the bay will vary according to whether the bar allows more or less water to enter. If more water is allowed to enter from the ocean, the density in the bay becomes less, and, if sufficient to keep the sodium chloride in solution—but not the calcium sulphate—beds of gypsum will be deposited. If, on the other hand, the entrance were closed sufficiently to allow only a very small amount of water to enter, or if the entrance were closed completely, the evaporation in the bay would cause all the more soluble salts to be deposited; and deposition would then cease.

The constant changing in the height of the bar at the entrance, then, would tend to give a bedded deposit in the bay: consisting of layers of limestone, gypsum, salt, etc. This would account for the reversal of the natural order of deposition of the

¹The total NaCl being to the total $\text{CaSO}_4 = 27.11:1.75$ this amount is relatively small. Almost all analyses of rock salt show at least traces of CaSO_4 . (Hubbard).

salts from sea water, found in many deposits: as for example, where gypsum is found resting on the top of beds of salt. It can readily be seen therefore, that if after a bed of salt had been deposited, the influx of water were increased, gypsum would be deposited on the top of the salt.

The fact that few, if any fossil remains are found in the salt formations is accounted for by the fact that, as the waters become more concentrated, the fish naturally seek the higher and less concentrated parts of the bay, and finally pass out altogether. Confirmation of this fact has been noted in one of the large basin-like arms of the Caspian Sea, where, at the present time, salt is being constantly deposited, consequently, fewer fish are found in this bay than in other parts of the Caspian Sea.

Another evaporation theory to account for thick deposits of salt was proposed by Walther¹, who has taken strong exceptions to the Bar Theory. This theory has been concisely summarized by Dr. Chas. W. Cook in a recent publication of the Michigan Geological Survey.² Cook, dealing with Walther's theory, says:—

From his (Walther's) studies of the desert and the salt deposits there found, he is led to believe that too much emphasis has been placed upon laboratory experiment without proper consideration of climatic factors. Man, being an inhabitant of the more humid regions, and almost entirely ignorant of the processes of the desert, has attempted to hypothesize conditions which would produce salt deposits in a more or less humid climate. Walther gives the conditions for the formation of salt deposits as follows:—

1. A solution of any source and any concentration.
2. A desert climate with greater evaporation than precipitation.
3. A desert climate with strong insolation, occasional snows and periods of cold, violent storms, wandering dunes and driving dust."

As to the source of the solution, it may have resulted from the cutting off of an arm of the sea; it may be due to the solution of sea salts contained in marine sediments of former geological periods. In arid regions the rain water sinks into the surface to a greater or less depth and is then returned to the surface by capillary action, and is evaporated with the deposition of the salts in solution, which are then subject to transportation by winds and succeeding rains.

The second factor mentioned above, i.e., the excess of evaporation over precipitation, is considered by Walther to be the controlling factor in the formation of salt deposits. He says that it makes no difference whether the evaporation occurs 400 meters below sea level, as in the case of the Dead Sea, or at an elevation of 1,500 meters, as in the case of Great Salt Lake; whether it is sea water spread out on a flat shore or in Thibet far from the ocean; and whether a flat sand bar separates a bay from the sea, or great bodies of saline river water are evaporated in small basins far from the sea.

¹Das Gesetz der Wüstungsbildung, pp. 140-156.

²Publication 15, Geol. Series 12, p. 37. Cook.

The characteristic phenomena included under the third heading are believed by Walther to account for certain features of salt deposits which, on the basis of laboratory experiments, are shown to require high temperatures or great pressure. In evaporating solutions in the laboratory heat is applied from below, whereas in nature it is applied to the evaporating surface. Also it has been found that certain compounds which in the laboratory require for their formation temperatures far higher than that of the water of any ponds, lakes or seas, are produced also under the influence of low temperatures or great changes in temperature such as would result from the melting of snow in saline solutions. The fact that deposits of sodium chloride of great thickness and purity exist may be due to the action of travelling dunes which, advancing upon the salt lake or marsh, "suck up" by capillarity the mother liquor, upon the further evaporation of which, the salts therein contained are deposited in a disseminated condition and therefore subject to the play of the wind. This may carry the dunes on until a later rain re-dissolves the salts from the dunes and concentrates them in depressions between dunes, giving rise to deposits of mother liquor salts free from gypsum and sodium chloride. Thus we see that in desert regions there are other means of transportation for the salts than running water.

(3) Dome Theory of Harris.

In order to account for the peculiar salt deposits occurring in Louisiana and Texas, G. D. Harris, State Geologist of Louisiana, put forward the theory now known as the Dome Theory.¹

Harris, referring to the prominent topographical dome-like elevations known as the "Five Islands," or the "Salt Islands" of Louisiana says:—

They are comparatively elevated, island-like areas that rise abruptly above the low marshy country lying nearly at tide level, and form the most conspicuous landmarks for hundreds of miles along the coast of the Gulf of Mexico.

The salt deposits occurring in these "domes" are circular to elliptical in shape, and are very remarkable, since they are of great depth relative to their diameter. The absence of prominent elevation does not necessarily mean the absence of salt deposits, for, according to Harris:—

Recent exploration has revealed many more of these salt-deposits, most of which do not form topographic islands, but are planed down by erosion to the level of the surrounding country.

The Dome theory of Harris may be briefly stated as follows:—

Meteoric waters entering the pervious layers to the north, gradually descend to greater and greater depths as they travel

¹The publications in which Harris describes this theory are: Geol. Surv., Louisiana, Bulletin No. 7, Report of 1907. Economic Geology, No. 1, Vol. IV, Jan.-Feb., 1909, pp. 12-34.

towards the Gulf of Mexico. These waters become heated, and take into solution many salts. Ascending through joints and fissures to higher levels, the temperature of this water—which has become a saturated solution—is decreased with the precipitation of the salts held in solution. Crystallization of the salt results, and the power exerted by the growing crystals is supposed to cause sufficient pressure to form the dome structure common to these deposits. Harris states that probably the salt in the first place was deposited in lower strata by ordinary evaporation methods.

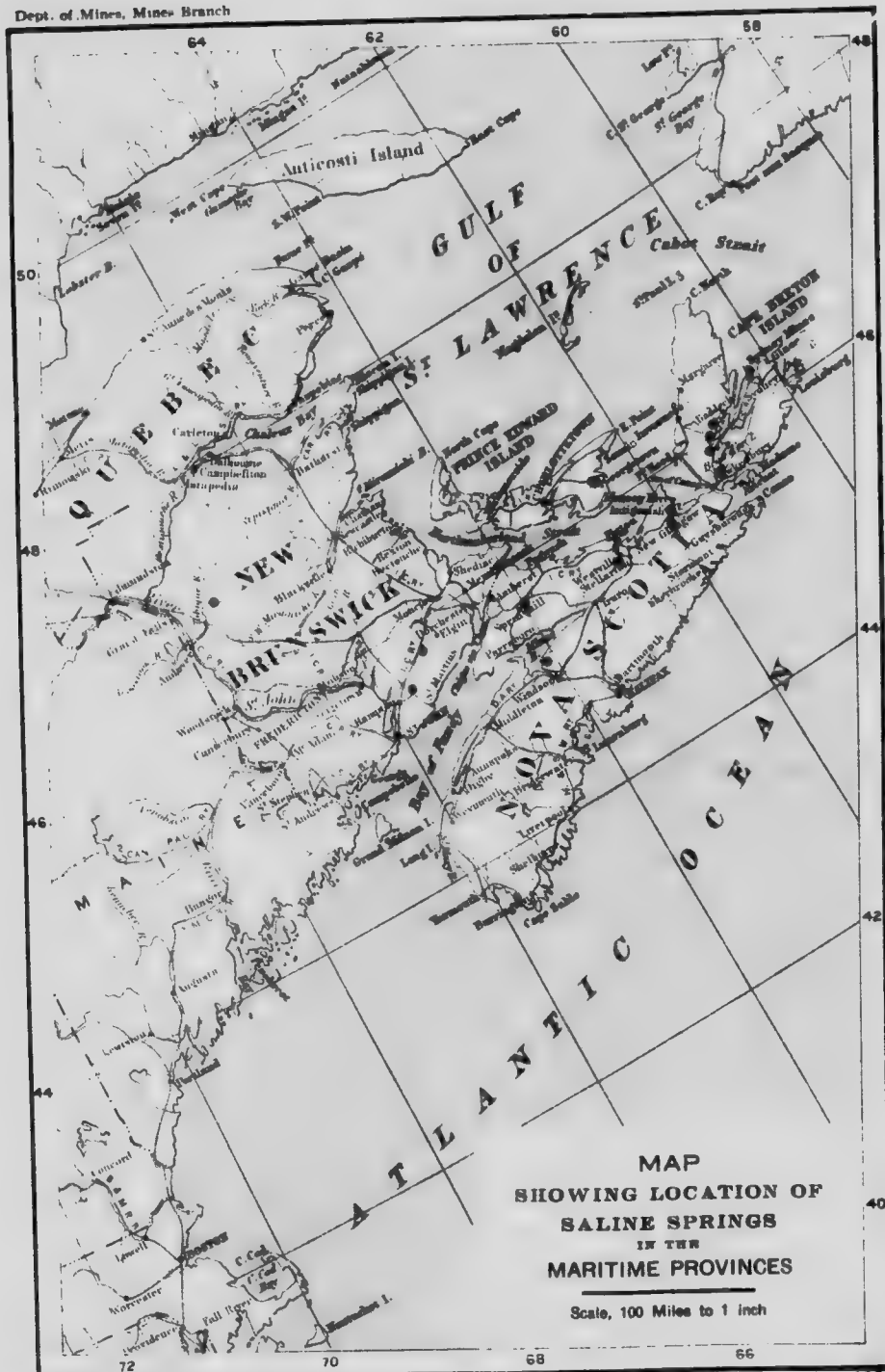
(4) Natural Brines.

Natural brines are found in many parts of the world; and many theories have been put forward to account for their origin. The most important theories may be classed as follows:—

- (a) The leaching out of salt beds by meteoric waters.
- (b) The leaching out of salt crystals disseminated through stratified rocks.
- (c) From original sea water enclosed or imprisoned in a porous stratum.

The variations and combinations involved in these theories, however, are so numerous, that it is almost impossible to assign any definite origin to any one brine occurrence.





CHAPTER III.

SALT OCCURRENCES IN THE MARITIME PROVINCES
AND QUEBEC.

Nova Scotia.

In the province of Nova Scotia no deposits of salt have, so far, been discovered; but numerous saline springs of a greater or less degree of salinity are known to occur. These springs, where noted, seem to have their origin from the beds of the Lower Carboniferous formation, and are closely associated with the gypsum deposits which occur so extensively in this formation throughout the province. Numerous drill-holes have been put down throughout the province, many of them passing completely through the Lower Carboniferous formation, but in none of them has rock salt been found. It is, therefore, probable that these springs obtain their salt from the leaching out of the smaller quantities of salt from the gypsum and limestone beds of the Lower Carboniferous formation by the surface waters, hence there is little probability of deposits of salt being found—except, perhaps, in small isolated patches—or of obtaining brines of any greater degree of salinity than those at present known.

Attempts have been made from time to time to manufacture salt on a commercial scale from these springs; but they have all been abandoned. At the present time there is no production of salt in the province. The weakness of the brine, and the consequent high cost of production, have, so far, made it impossible to compete with the Ontario salt, or that imported from the United States, or Great Britain.

A few of the places at which brines occur will be mentioned. But since none of these springs are being operated at the present time, very little official data could be obtained by visiting the different localities; and the following notes are, of necessity, from previous published data on the subject. The locations of the more important springs are indicated on Map 328.

WHYCOCOMAGH.

Brine springs have been noted half way between Baddeck and Whycomagh, on the road running along the northwest shore of St. Patrick's Channel. Mr. Chas. Robb¹ in referring to these springs says that they

Appear to issue from rocks lying towards the base of the Lower Carboniferous formation, and are situated on the north side of the Little Narrows of Bras d'Or Lake, between the shore and the road, about 12 miles southwest of Baddeck, on land belonging to James Watson, miller. Here several saline springs of more or less strength occur in close proximity over an area of about 12 acres of flat marshy land. Much hydrated peroxide of iron is deposited in the water courses, the odour of sulphuretted hydrogen pervades the atmosphere in the vicinity, and the vegetation is destroyed around all the springs. The strongest spring, from which about a gallon was taken for analysis, appeared to me to discharge from 100 to 200 gallons per minute. It was stated by evaporating in two common iron pots, each containing about three gallons, from two to three bushels of salt were made per day. I was further informed that it had been proposed many years ago to establish works for the manufacture of salt at this place, and that machinery had actually been ordered for that purpose, but I am not aware for what reason the undertaking was abandoned.

The sample taken by Mr. Robb from this locality was analysed by Mr. C. Hoffman, with the following results:—

The filtered brine contained in 1,000 parts:—

Sodium.....	19.9423
Potassium...	0.1019
Calcium.....	1.6709
Magnesium.....	0.0403
Iron.....	absent
Alumina.....	traces
Chlorine.....	30.9585
Sulphuric acid (SO ₄).....	4.0162
Silica.....	traces
or:—	
Chloride of sodium.....	50.6881
" potassium.....	0.1942
" magnesium.....	0.1593
Sulphate of calcium.....	5.6810
Alumina.....	traces
Silica.....	traces
	56.7226

¹Geol. Survey, Can., Rept. of Progress, 1873-74, p. 180-181.

ANTIGONISH.

In the vicinity of the village of Antigonish and in the adjacent district numerous saline springs and ponds are found. Mr. Hugh Fletcher makes reference to these springs as follows¹:—

Salt springs and ponds are found everywhere in the neighbourhood of the gypsum, as at Pomquet, and South Rivers, Brierly Brook, Addington Forks and other places. Salt was made many years ago from the salt pond near the town of Antigonish. In May, 1866, a company called the Nova Scotia Salt Works and Exploration Company, was incorporated under the management of Mr. Josiah Deacon, to conduct boring operations to discover the source of the brine.² The first boring was sunk on Town Point, near the mouth of the harbour, a six-inch bore-hole, lined with iron tubing, being driven through a considerable thickness of soil and clay, then through a thick band of gypsum into sandstones, without finding any indication of brine; so that further operations in this locality were abandoned.

Encouraged by indications of salt water on the surface where the railway station now stands, a second bore-hole was put down here; and a nine-inch cast-iron pipe sunk through sixteen feet of gravel, full of weak surface brine. The auger then passed through red, blue and brown marl, with thin bands of fibrous gypsum; then through several layers of magnesian sandstone, striking a bed of gypsum 141 feet from the surface.

After penetrating 18 feet into the gypsum, there was a flow of pure, strong, limpid brine from a cleft, which flowed nearly to the surface, could only be lowered a few feet by pumping, and discharged a large volume of sulphuretted hydrogen gas. A steam engine was erected for pumping, and furnaces, tanks and evaporating pans of large dimensions, constructed for the production of salt. After the manufacture of a considerable quantity of salt, the strength of the brine became very much reduced. Another borehole was accordingly put through clays to a depth of 650 feet, but finding no indications of brine, that of the other boring being too weak for use, and working capital exhausted, the work was abandoned.

SPRING HILL, CUMBERLAND CO.

Attempts have been made to manufacture salt at Spring Hill from a brine spring which recorded about 30° on the salinometer; but operations were soon abandoned.

¹Geol. Survey of Canada, Vol. 2, p. 124P.

²Geiser's Geology, p. 92; How's Mineralogy of Nova Scotia, p. 145; Trans. Nat. Sc., Vol. IV, p. 74; Acadian Geology, p. 350; Report of Commissioner of Mines for 1874, p. 58.

SALT SPRINGS, PICTOU CO.

Dr. Henry How¹ mentions a spring occurring at Salt Springs, Pictou County, of which the following is an analysis:—

Carbonate of Lime.....	3.775	grains per Imp. gal.				
“ “ Magnesia.....	2.932	“ “ “ “				
“ “ Iron.....	0.181	“ “ “ “				
Silica.....	0.560	“ “ “ “				
Sulphate of Lime.....	154.730	“ “ “ “				
Chloride of Magnesium.....	27.330	“ “ “ “				
“ “ Calcium.....	51.910	“ “ “ “				
“ “ Sodium.....	4133.500	“ “ “ “				
	4374.918	“ “ “ “				

Specific gravity at 53° F. = 1046.69
Sodium chloride per cent. 5.9.

WALTON, HANTS CO.

A brine spring is also noted by Dr. How² as occurring at Walton, but the sodium chloride content is only 1.1 per cent.

CHEVERIE, HANTS CO.

In two boreholes drilled at Cheverie, strong brines were encountered at depths of 1,400 and 1,870 feet, respectively. The brine was reported as having a strength of 76° by the salinometer.

New Brunswick.

As with Nova Scotia, so with New Brunswick, no beds of salt have, so far, been discovered. Several localities, however, are known where brine springs have been observed. These springs have their origin in the rocks of Lower Carboniferous age. Small quantities of salt were manufactured each year from the brine of these springs; but for the last ten years, operations have ceased. The best known localities are at Sussex, and Salt-spring brook—both in Kings county; and on the Tobique river, Victoria county.

¹Trans. Nova Scotia Inst., of Nat. Sci., Vol. 1, Pt. 3, pp. 75-80.
²How's Mineralogy of Nova Scotia, p. 61.

SUSSEX, KING'S COUNTY.

Dr. L. W. Bailey¹ in referring to the springs at this locality says:—

As nearly as can be ascertained, the first operations for the manufacture of salt near Sussex were begun fully one hundred years ago, the quantity manufactured being, however, but small, very variable in amount, and employed wholly for local consumption. A similar description would, to a large extent, apply to more recent undertakings in the same direction. The present proprietor (Mr. Geo. N. Hendricks) commenced work in 1887, since which time, on an average, about 150 barrels of salt per year have been made, each barrel holding four bushels. During the year 1897, 140 barrels were made, at a cost of about \$2 per barrel. The salt is sold for \$3 per barrel, and is especially esteemed for table and dairy use.

The salt is made by evaporation, two furnaces being employed, side by side, and having over them one pan made of boiler-plate holding 2,000 gallons and one holding 400 gallons. There are also two kettles holding 200 gallons each, and four holding 150 gallons each. These latter kettles, weighing 1000 pounds, and costing \$50 each, are found to be very liable to crack and sometimes last only a single season, thus increasing materially the cost of production, as well as giving uncertainty to the amount of product. Wood, in four-foot lengths, is burnt in one end of each furnace, and the fire is continued from Monday morning until Saturday night. Only two men are employed, one for the day and the other for the night, and great care is taken to secure a product which is pure and clean. Work is carried on in warm weather only. During the time the works were running in 1897, they turned out a little over twenty-one barrels per week; but there is plenty of brine to run a much larger plant, while if, by boring, a brine of greater strength were reached and more economical methods of concentration were employed, the yield could, no doubt, be very largely increased. There would be no difficulty in selling a larger quantity. The strength of the brine at present is twenty per cent.

SALINA, SALT SPRING CREEK, KINGS COUNTY.

About 30 miles south of Sussex, brine springs were sampled by Mr. R. Chambers, in 1895. The brine sampled was taken from a boring 330 feet in depth. The analysis was as follows²:—

Potassium chloride.....	19.963	grains per	Imp. gal.
Sodium "	1293.648	"	"
Magnesium "	22.315	"	"
Sulphate of lime.....	268.212	"	"
Sulphate of magnesia.....	11.336	"	"
	1665.474	"	"

No attempt has been made to manufacture salt from this brine.

¹Geol. Surv., Can., Vol. X, p. 121M.

²Annual Rept. Geol. Survey, Can., Vol. VII, p. 55R.

TOBIQUE RIVER, VICTORIA COUNTY.

Mention is made in a number of the earlier reports of the Geological Survey of Canada, of the existence of brine springs in the vicinity of the Tobique river, Victoria County.

Quebec.

In the province of Quebec there are a number of mineral springs which contain sodium chloride; but these are either too weak in this constituent, or else contain too much earthy chlorides to permit of their being employed for the manufacture of salt.



LEGEND

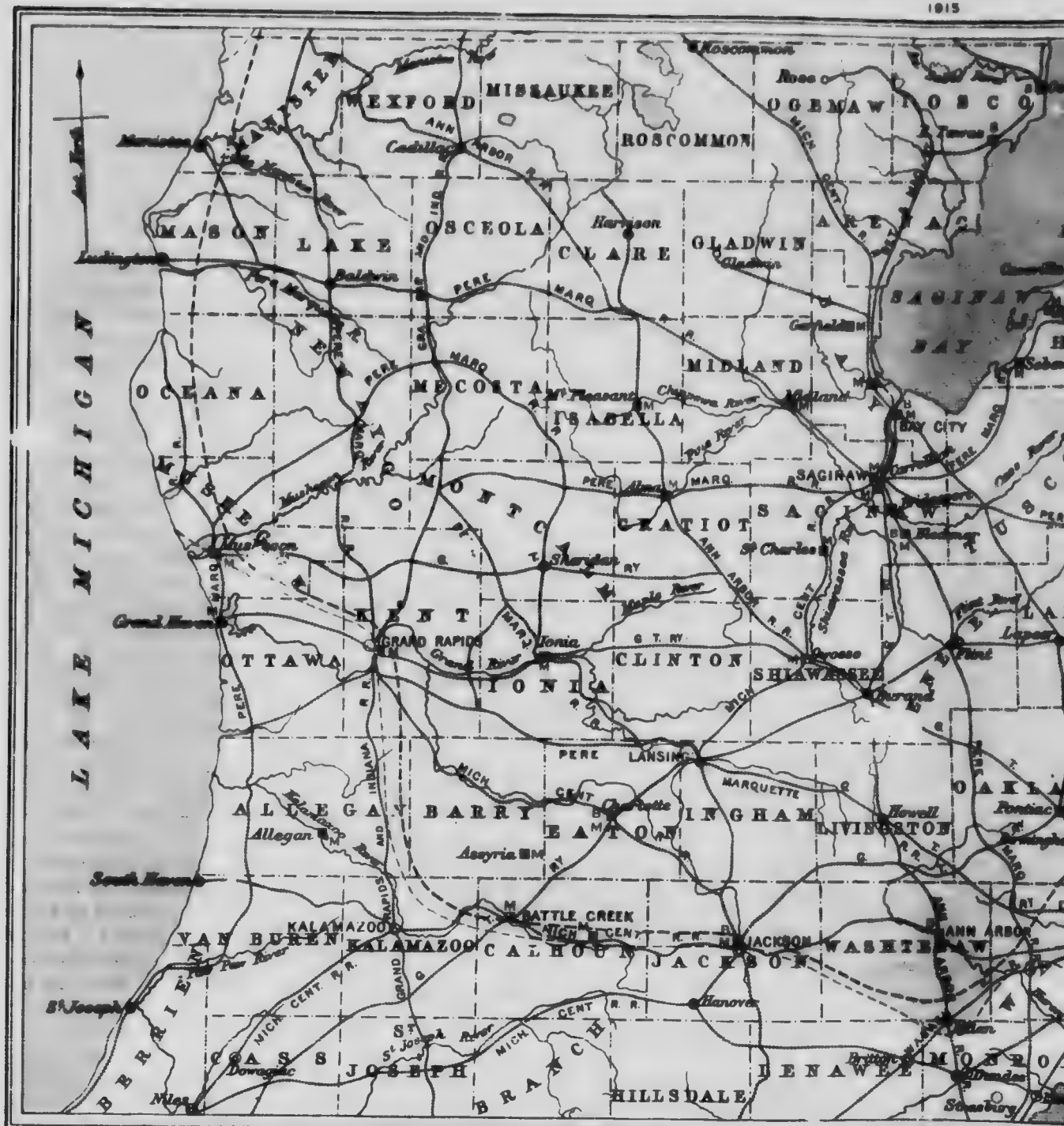
- Probable boundary of known productive area of Salina
- Salina unexplored in area
Probable depth to Salina in centre of this basin is 4500' feet
- Drill-holes penetrating Salina which encounter Rock Salt
- ⊕ Drill-holes penetrating Salina which do not encounter Rock Salt
- ⊕ Drill-holes encountering only brines
The horizon of the brines from these wells is not known. The character of the rock encountered in wells seems to indicate the absence of Salina in this area
- Drill-holes penetrating the Berea Sandstone
- Drill-holes penetrating the Marshall Sandstone

NOTES

The brines from the Berea are very highly saturated, but of late years have not been used as a source of salt. Where these brines are encountered at depth, there is a marked increase in the percentage of bromides and the bittern was formerly used for the manufacture of bromine.

The Marshall Sandstone near the centre of the basin yields a strong brine which is the source of most of the salt in the Saginaw valley.

Figures in red after drill-holes show depth at which rock salt or brine was first encountered.



E.E. Bana, Chief Draughtsman.
D. Westwood, L. draughtsman.

ONTARIO-MICHIGAN SALT

SHOWING PROBABLE LIMIT OF PRODUCTION



LEGEND

- Probable boundary of known productive area of Saline.
- Saline unexplored in area. Probable depth to Saline in centre of this basin is 4000' feet.
- Drill-holes penetrating Saline which encounter Rock Salt
- Drill-holes penetrating Saline which do not encounter Rock Salt.
- ⊕ Drill-holes encountering only brines. The horizon of the brines from these wells is not known. The character of the rock encountered in wells seems to indicate the absence of Saline in this area.
- B Drill-holes penetrating the Berea Sandstone
- M Drill-holes penetrating the Marshall Sandstone.

NOTES.

The brines from the Berea are very highly saturated, but of late years have not been used as a source of salt. Where these brines are encountered at depth, there is a marked increase in the percentage of bromides and the bottom was formerly used for the manufacture of bromine.

The Marshall Sandstone near the centre of the basin yields a strong brine which is the source of most of the salt in the Saginaw valley.

Figures in red after drill-holes show depth at which rock salt or brine was first encountered.

SALT BASIN
PRODUCTIVE AREA

CHAPTER IV.

SALT IN ONTARIO.

Introduction.

Ontario, at the present time, is the centre of the salt industry of Canada. The salt obtained in this province is recovered by the evaporation of brine which has leached out rock salt from beds which occur in the Salina formation in the southwestern part of the Province bordering on Lake Huron; the St. Clair river; lake St. Clair; and the Detroit river. It is impossible, with our present knowledge, to determine definite boundaries of the salt basin; but, as far as it now stands proved, the area underlain by salt in Ontario is approximately contained within lines joining the towns of Inverhuron, Teeswater, Brussels, Seaforth, London, St. Thomas, on the west; and Thamesville, Dresden, across lake St. Clair, through Elmstead to a point on the Detroit river between Amherstburg and Sandwich. This approximate boundary of the salt basin has been shown on the accompanying map (Map No. 329). The area enclosed within this boundary in Canada is about 3,000 square miles.

The salt beds are known to vary in thickness. In some wells they occur in thin beds interstratified with dolomite and shale; the total combined thickness of all these beds varying from 100 to 200 feet. In other localities, as in the case of the beds at Windsor, the salt beds are of great thickness, one bed alone having a thickness of 200 feet. The average depth at which the salt is found is in excess of over 1,000 feet, there being a gradual increase in depth of the beds as one goes farther south.

The production from a few wells has hitherto been sufficient to supply the domestic demand, and little exploration has been carried on by which the area underlain by salt can be definitely outlined. There has, however, been a great deal of exploratory work in connexion with the development of petroleum and natural gas fields. Where these boreholes extend below the salt

horizon, they give evidence of either the presence, or the absence of salt.

From the records available, it would appear that within the area mentioned, and outlined on the accompanying map, the salt beds are practically continuous; there are, however, some limited areas within these boundaries where—according to the records of drill holes that have penetrated below the Salina—there are no salt beds.

The southeast boundary of the salt area is at present unknown, as no drill records are obtainable from the district along the north shore of Lake Erie between St. Thomas and Chatham. Records from a hole at Orford, Kent county, show 171 feet of salt, at 1,510 feet below the collar of the hole; while another from Glencoe shows 104 feet of salt, at 1,290 feet below the surface. These records lead one to believe that possibly the beds are dipping to the southeast and may be found by deeper drilling in the vicinity of Lake Erie.

The southwestern boundary merely marks the dividing line between the area beneath which salt beds are encountered, and the area where brines of a more or less density were found, although no rock salt was obtained.

The salt beds are supposed to extend under the Detroit river; Lake St. Clair, St. Clair river, and the southern part of Lake Huron, since rock salt has been found in the Salina formation in the State of Michigan, on the opposite side of the International Boundary.

WELL RECORDS.

To give some idea of the depths at which salt occurs; the thickness of the beds; and other conditions, a number of logs are given of wells drilled in the salt basin. A table has been introduced to show the depths at which salt beds have been encountered in a number of the more prominent wells.

Among the earlier borings made in this region, the most important was the diamond drill-hole put down by Mr. Henry Attrill in 1876, with a view to determine the nature and extent of the salt beds. The results¹ of the drilling, as interpreted

¹Geol. Surv. Can., Vol. XV, Pt. S, pp. 217, 222-226S.

from the log and the cores by Dr. T. Sterry Hunt, have been summarized by him as follows:—

	<i>Thickness.</i>		<i>Total Depth.</i>	
	<i>Ft.</i>	<i>In.</i>	<i>Ft.</i>	<i>In.</i>
Clay, gravel and boulders.....	78	9	78	9
Dolomite, with thin limestone layers.....	278	3	357	0
Limestone, with corals, chert and beds of dolomite...	276	0	633	0
Dolomite with seams of gypsum.....	243	0	876	0
Variegated marls, with beds of dolomite.....	121	0	997	0
Rock-salt 1st bed.....	30	11	1027	11
Dolomite, with marls towards the base.....	32	1	1060	0
Rock-salt 2nd bed.....	25	4	1085	4
Dolomite.....	6	10	1092	2
Rock-salt 3rd bed.....	34	10	1127	0
Marls with dolomite and anhydrite.....	80	7	1207	7
Rock salt 4th bed.....	15	5	1223	0
Dolomite and anhydrite.....	7	0	1230	0
Rock-salt 5th bed.....	13	6	1243	6
Marls, soft, with anhydrite.....	135	6	1379	0
Rock-salt 6th bed.....	6	0	1385	0
Marls, soft, with dolomite and anhydrite.....	132	0	1517	0

"The drilling thus showed a total thickness of salt of 123 feet in a distance of 388 feet divided up into six beds, ranging from six feet to nearly thirty-five in thickness. Of these the first bed has intercalated with it layers of dolomite, and is stained by earthy matter. This bed would not be pure enough for mining.

"The second and third beds which are separated by a layer of less than seven feet are very pure. They measure together over sixty feet, and represent practically one great mass of rock-salt.

"The fourth bed, measuring from 1,207 to 1,223 feet is uneven in purity, only the upper two feet and the lower two feet nine inches of the core were saved. The former was somewhat impure, the lower was white salt with layers of dolomite.

"The fifth bed measures thirteen and a half feet, and from what can be judged, from what was obtained of the core (five and a half feet) the salt is impure though white in portions.

"The sixth bed is pure white and translucent and measures six feet."

CLINTON WELL.

(Stapleton Salt Works.)

	<i>Thickness.</i>	<i>Total Depth.</i>
Drift.....	67 ft.	67 ft.
Limestone.....	413 "	480 "
" cherty, and dolomitic.....	204 "	684 "
".....	176 "	860 "
" cherty.....	36 "	896 "
Shale, limestone, gypsum, and marls.....	255 "	1151 "
Rock salt (1st bed).....	15 "	1166 "
Shale, gypsum, and salt.....	48 "	1214 "
Rock salt (2nd bed).....	25 "	1239 "
	1239 ft.	

KINCARDINE WELL.

(Ontario Peoples' Salt and Soda Co.)

	<i>Thickness.</i>	<i>Total Depth.</i>
Drift.....	91 ft.	91 ft.
Limestone.....	509 "	600 "
Shale, red and blue.....	140 "	740 "
Limestone.....	30 "	770 "
Shale, red and blue.....	125 "	895 "
Rock salt.....	14 "	909 "
	909 ft.	

In both these wells, distinct water courses were encountered—at 250 and 500 feet respectively; the water from which supplies the solvent for the salt beds beneath.

PETROLIA WELL.¹

	<i>Ft.</i>	<i>Total Ft.</i>	<i>Formation.</i>
Drift.....	90	90	
Shale.....	240	330	Hamilton.
Cherty limestone.....	190	520	Corniferous
Dolomite.....	690	1210	

¹Ontario Bureau of Mines, Vol. XX, Pt. I, p. 254.

	Ft.	Total Ft.	Formation.
Salt.....	65	1275	Salina.
Dolomite.....	20	1295	
Salt, with dolomite.....	140	1435	
Dolomite.....	30	1465	
Salt.....	90	1555	
Salt, with dolomite.....	50	1605	
Salt.....	25	1630	
Dolomite.....	10	1640	
Salt.....	138	1885	
Dolomite.....	130	2015	
Salt.....	90	2105	Niagara.
Dolomitic lime.....	275	2380	
Shale.....	150	2530	
Red shale.....	275	2805	
Light shales.....	205	3010	
Dark shales.....	165	3175	Utica.
Limestone.....	772	3947	Trenton.

SARNIA WELL.

	Thickness. ft.	Total Depth. ft.
Drift.....	122	122
Black shale.....	40	162
Limestone.....	80	242
Shales.....	185	427
Limestone.....	30	457
Shales.....	46	503
Limestone.....	987	1490
Gypsum (anhydrite?).....	5	1495
Shales, and salt.....	15	1510
Salt.....	56	1566
Shales.....	18	1584
Salt.....	30	1614
	1614	

WINDSOR WELL.

(Canadian Salt Works Well No. 4.)¹

	Thickness ft.	Total Depth. ft.
Drift.....	133	133
Limestone.....	922	1055
Salt.....	30	1085
Limestone.....	25	1110
Break in record.....	35	1145
Salt.....	75	1220
Limestone.....	100	1320
Salt.....	70	1390
Limestone.....	30	1420
Salt.....	252	1672
	1672	

Well ended in limestone.

TABLE II.

Table² Showing Thickness of Beds and Depth at which Salt was Encountered in Ontario Salt Basin.

Locality.	Salt struck at depth of.		Thickness of salt.	
	Feet	In.	Feet	In.
Bruce county, Kincardine:—				
Total depth, 1,007 feet.....	993		13	
Huron county, Goderich, Attrill's diamond drill—				
Total depth, 1,517 feet.....	997		30	11
	1,060		25	4
	1,092		34	10
	1,027	7	15	5
	1,230		13	6
	1,379		6	

¹Ont. Bureau of Mines, Sixth Rept., p. 33.²Geol. Surv. Can., Vol. XV, Pt. S., p. 226.

TABLE 11.—Continued

Locality.	Salt struck at depth of.	Thickness of salt.	
		Feet	In.
Huron county, Goderich, Inter- national well—			
Total depth, 1,170 feet.....	1,054	19	
	1,103	24	
	1,130	32	
Huron county, Wingham:—			
Total depth, 1,185 feet.....	1,090	30	
Huron county, Brussels:—			
Total depth, 1,244 feet.....	no salt.		
Huron county, Brussels, $\frac{3}{4}$ mile southwest of above well:—			
Total depth, 1,000 feet.....	970		
Huron county, Blyth:—			
Total depth, 1,215 feet.....	1,125	90	
Huron county, Clinton:—			
Total depth, 1,239 feet.....	1,151	15	
	1,214	25	
Huron county, Seaforth:—			
Total depth, 1,135 feet.....	1,035	110	
Huron county, Hensall:—			
Total depth, 1,206 feet.....	1,090	116 with shale	
Huron county, Exeter:—			
Total depth, 1,251 feet.....	1,135		
Middlesex county, London, Asylum well:—			
Total depth, 2,250 feet.....	1,400	100 with shale	
Middlesex county, Glencoe:—			
Total depth, 1,510 feet.....	1,290	104 with shale	
Lambton county, Port Franks:—			
Total depth, 1,355 feet.....	1,245	110 with shale	

TABLE II.—Continued

Locality.	Salt struck at depth of.		Thickness of salt.	
	Feet	In.	Feet	In.
Lambton county, Petrolia:—				
Total depth, 1,505 feet.....	1,180		105 with shale	
	1,365		140 with shale	
Lambton county, Courtright:—				
Total depth, 1,665 feet.....	1,630		22	
Essex county, Windsor:—				
Total depth, Well No. 1, 1,167ft.	1,127		40	
Essex county, Windsor:—				
Total depth, Well No. 4, 1,672				
feet.....	1,055		30	
	1,110		75	
	1,320		70	
	1,420		252	

GEOLOGY.

The beds from which the salt is obtained are of Silurian age and are found in the Salina formation. This formation within the salt area overlies the Guelph and is overlain by the Monroe formation. The Salina, where exposed at the surface, consists mainly of thin bedded dolomites, pale grey or yellowish coloured, and greenish calcareo-argillaceous shales with some reddish layers. On the east shore of Lake Huron this formation outcrops infrequently between Goderich and the mouth of the Saugeen river from which it turns east and south—

Rounding the northern end of a wide syncline between Southampton and the head of Owen Sound and running thence southeasterly to the Grand river from which it takes an easterly course to the Niagara.¹

¹It is probable that some beds belonging to the Monroe, which have not yet been altogether differentiated from the Salina in Ontario are included within the area mentioned. The geology of Western Ontario has recently been revised by the officers of the Geological Survey but the results of the field work are not yet published. The surface distribution of this formation and the other associated formations above and below have all been re-mapped, and this work clears up many previously obscure points in the geology of the Ontario peninsula.

The thickness of the Salina formation ranges from about 300 feet at Niagara Falls, to 508 feet at Kincardine, and 775 feet at Goderich. In the lower part of this formation are found extensive deposits of rock salt and gypsum, (anhydrite,): the salt from which beds furnish the brine wells at Kincardine, Wingham, Clinton, Goderich, Seaforth, Sarnia, Windsor, and Sandwich.

ORIGIN OF THE ONTARIO SALT BEDS.

Many theories have been put forward to account for the extensive beds of salt found in the Salina. By far the greater number of writers on the geology of this district are in favour of the 'Bar' theory of formation. Lane¹ writing on the origin of the salt in the Salina formation in Ontario and Michigan, goes so far as to locate the bar in Ohio. On the other hand, Grabau and Sherzer² favour Walther's theory, and consider these deposits to have been formed under desert conditions, in an arid climate, the salt being obtained from—

The old sea-salt imprisoned in the Niagaran and earlier marine strata at the time of their formation under the sea.

Cook³ also favours this latter theory.

The data available are insufficient to enable one to formulate a satisfactory theory with respect to the origin of brines which occur in numerous drill-holes in Essex and Kent counties, or of similar brines found in horizons higher than the Salina which occur in wells located within the boundaries of the salt basin, some of which also penetrate the underlying Salina salt beds. These brines may represent mother liquors from which the rock salt of the Salina was deposited and imprisoned later in the material which was laid down upon the Salina, or they may owe their origin to the partial erosion of Salina salt deposits. In the former case, one would expect their composition to be similar to that of a bittern. At present no analyses of these brines are available.

¹Geol. Surv. Mich., Vol. V, 1895, Part II, p. 27.

²Geol. and Biol. Surv., Mich., Pub. 2, Geol. Ser. 1, 1909, pp. 235-6.

³Mich. Geol. and Biol. Surv., Pub. 15, Geol. Series 12, 1913, pp. 92-94.

HISTORY OF THE SALT INDUSTRY IN ONTARIO.

The discovery of salt in Ontario dates back to the year 1866. In that year, when the oil excitement was at its height in western Ontario—due to oil having been discovered to the south—a company was formed at Goderich, organized by a Mr. Samuel Platt, with the object of drilling for oil. This company, with a subscribed capital of \$10,000, commenced drilling on the north bank of the Maitland river, to the east of the bridge. The drill passed through a series of layers of greyish limestone of varying hardness, to a depth of 686 feet, without encountering any indications of oil; so the stockholders decided to abandon the enterprise. Mr. Platt, however, decided to continue drilling at his own expense, especially since the County Council had offered a bonus of \$1,000, and the city a bonus of \$500 providing drilling was continued to a depth of 1,000 feet. His efforts were amply rewarded, for, at a depth of 964 feet from the collar of the hole, he encountered a solid bed of rock salt into which he bored for a distance of 60 feet, thus completing 1,000 feet, and securing the above mentioned bonuses.

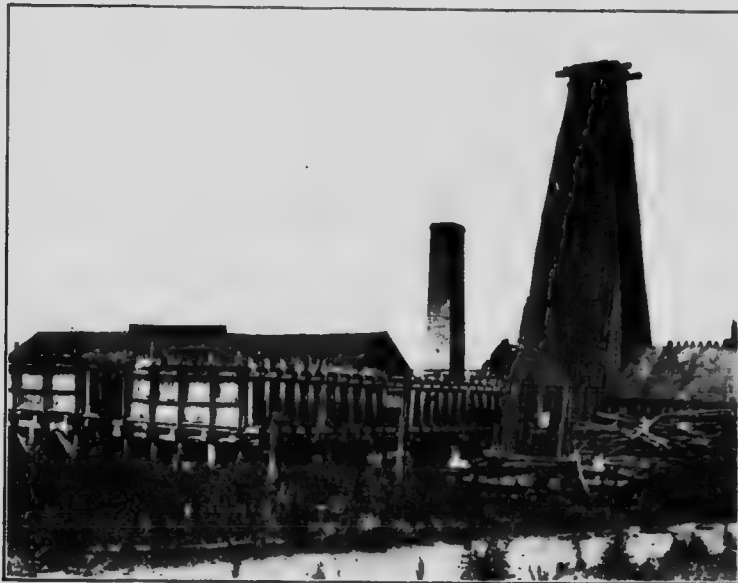
Upon encountering salt, the shareholders who previously had abandoned the work, desired to be allowed to pay up their assessment and were allowed to do so by Mr. Platt. The capital of the company was increased to \$14,000, and was incorporated as the Goderich Petroleum Company, and in September, 1866, pumping of brine commenced. The product made from this brine was sold to George Rumball & Co., who marketed it.

The record of the hole was carefully kept by Mr. Platt, who furnished the information to Dr. T. Sterry Hunt¹ who worked out the record as follows:—

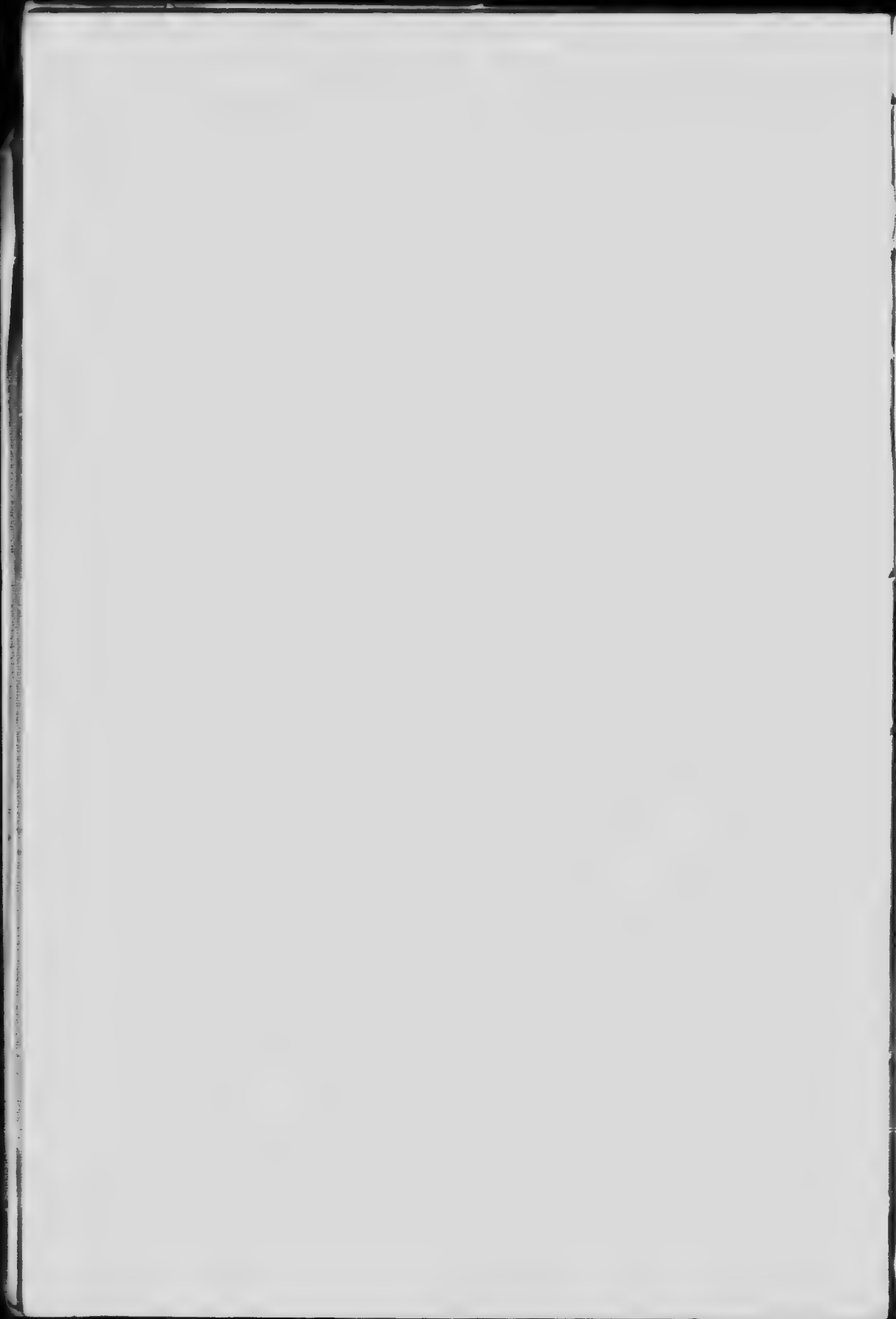
¹See Rept. Progress Geol. Surv. Can. 1866, pp. 268-269.



A. Plant of North American Chemical Co., Goderich, Ont.



B. Settling tanks, Stapleton Salt Works, Clinton, Ont.



GODERICH WELL (1866).

	Thickness.	Total Depth
Surface gravel.....	25 ft.	25 ft.
Limestone (blue, white and grey).....	335 "	360 "
Sandstone.....	85 "	445 "
Limestone (blue, white and grey).....	175 "	620 "
Sandstone.....	40 "	660 "
Limestone (blue, white and grey).....	26 "	686 "
Sandstone (traces of oil).....	27 "	698 "
Chert (with calcspar).....	12 "	725 "
Magnesian limestone (white and yellowish).....	75 "	800 "
Shales (bluish and reddish with several beds of white gypsum).....	164 "	964 "
Rock salt ¹ (interstratified with soft blue clay. Salt in layers of 1 foot or more in thickness).....	41 "	1005 "
Hard limestone.....	5 "	1010 "
Total depth		1010 ft.

At the time the first salt was encountered Mr. Platt furnished a sample of the brine to Dr. Hunt who reported on it as follows²:—

It was colourless and transparent, and its temperature was about 50° F. Its specific gravity, at 60° F., was 1.205.

	In 1000 pts. by wt.	In 100 pts. of solid residue.
Chloride of sodium.....	259.000	99.018
Chloride of calcium.....	.432	.165
Chloride of magnesium.....	.254	.097
Sulphate of lime.....	1.882	.720
	261.568	100.000

It is therefore a saturated brine, a wine-pint of it weighing 8,783 grains, and containing 2,274 grains of pure salt. . . . This brine is remarkable for its purity, the solid matters from its evaporation containing over 99 per cent of salt. . . . I¹ results from this that the salt manufactured from the Goderich brine must be of exceptional purity, since it will hold less than one per cent of foreign matters, while the Onondaga solar salt contains 1.15, the Saginaw 2.0, and the Turk's Island 2.34 per cent of impurities. In all of these, a portion of the foreign matter is taken away in the process of manufacture, while no draining or other mode of purification will be needed with the Goderich brine, to make from it salt surpassing the finest hitherto known.

As soon as the well was in shape for pumping the brine, the Goderich Salt Co. (as it was then called) constructed two blocks of 52 kettles each: the kettles ranging in capacity from

¹Rock salt formed 30 ft. of this thickness.

²Geol. Surv. Can., 1866, p. 269.

120 to 140 gallons. Thus the total capacity of the plant was in the neighbourhood of 100 barrels per day.

The salt produced found a ready market, so that at the end of the first year's operation the profits were considerable, dividends 5 per cent, having been distributed among the shareholders. The price then obtained for the salt was \$1.25 per barrel at the works.

The settling method was soon found to be expensive, hence it was discarded in favour of the pan method of evaporation.

The attendance of this pioneer company gave great impetus to the industry, so that by the next summer the valley was filled with operations. About the year 1872, the following block with the enumerated capacity in barrels per day were in full operation: "The Goderich" 200 bbls. (this was the pioneer well), "Maitland" 100; "Prince," 100; "Victoria," 100; "Huron," 100; "Dominion," 200; "Ontario," 150; "Tecumseh," 150; "Hawley's," 200; "Inniskillen," 200; "International," 600; and "Platt's," 150 (Platt having severed his connexion with the original company and erected works of his own).

In the meantime, drilling operations had been carried on with good success at Clinton and Seaforth, and at both places salt was encountered, and plants erected. The fact that wood fuel was cheaper at these latter places enabled them to supply the Canadian market at lower prices than from the Goderich wells, and in consequence a number of the plants at the latter place were forced to close down.

In the year 1879, there were only four of the Goderich plants in operation: namely: "Platt's"—making 150 barrels per day; "Tecumseh"—owned by A. Hodge, 75 barrels; "Hawley's"—200 barrels; and the "International"—600 barrels. This last mentioned Company was operated by the Seaforth Syndicate and was, up to that time, the largest salt works in Canada. The following description of this plant, taken from the County of Huron Atlas, is of interest:

Situated on the bank of the lake, about a mile south of the harbour, at a place where a deep ravine runs down to the lake, the ravine is utilized through which to run a railroad or tramway down to a wharf owned by Mr.

McEwan (of the Seaforth Syndicate); and here when the lake is calm, large vessels are loaded with the salt from these works, which, in common with the greater part of the Goderich salt, finds its chief outlet in Chicago and Milwaukee, since being shut off from the eastern markets by the product of the Seaforth and Clinton wells. The well of these works (International) is over 1,200 feet deep, having penetrated the first layer of salt at a depth of about 1,050 feet, after which about 100 feet of limestone formation was encountered before reaching the second layer of saliferous rock, the thickness of which is at present undetermined. Connected with the "International" are four "pans," of about 110 X 30 feet, and eighteen inches deep; but only three of these are in operation. About twenty cords of wood are used each twenty-four hours, and a force of thirty men are employed.

The salt industry in Canada, was, from the very first, met by determined opposition and competition from the salt manufacturers of the State of New York; who, up to that time, had controlled the whole of the Canadian market. All reductions on the part of the American manufacturers, were met by the Canadian producers, and in time, the superior quality of the Canadian product secured the whole of the Canadian trade.

Since the year 1876, salt has been encountered in other wells both north and south of Goderich, so that now the area under which salt is to be found is pretty well defined. (See Map No. 327).

In the year 1878, the first shipment of Canadian salt—consisting of 200 barrels—was made to Winnipeg, via Duluth, Pembina, Emerson, and by boats down the Red river.

Since that time (1878), the industry has had a varied career, showing, on the whole, a gradual increase. Numerous "Associations"—formed, from time to time—have obtained control of the selling of the products from all the different wells; agreements being made, in each case, to take a certain quantity from each manufacturer yearly. In the last few years, however, the industry has increased to such an extent that these associations became obsolete, and now all the plants do their own selling.

Improvements in the methods of evaporating the brine and handling the salt have been introduced into a number of the works, so that several of the plants now compare, very favourably, with the best on the continent.

OPERATING PLANTS.

There are at the present time twelve plants being operated in the Ontario salt region for the production of salt. A short description of each of these plants is given.

THE ONTARIO PEOPLE'S SALT AND SODA COMPANY.

Locality: Kincardine, Ont.

Transportation facilities: Grand Trunk Railway, and wharf on Lake Huron, from which shipments can be made by water. Plate II, A and B shows the shipping facilities from this plant.

This Company obtains its brine from a well 935 feet deep. The brine is pumped into two tanks 20 ft. $\times$ 20 ft. $\times$ 5 ft. deep, from which it passes through a heater—heated by exhaust steam from the engine—thence to an evaporating tank 100 feet long, by 13 feet wide, and 7 feet deep in the centre. This tank is of special construction, being V-shaped, with a scraper-conveyer running along the full length of the bottom. This conveyer continuously removes the salt as it is formed, and by means of an elevator at one end the salt is placed in a hopper bin. The evaporating tank is made of $\frac{1}{4}$ " boiler plate, lined on the inside with stone flags 2" thick, and lagged on the outside with plank and sawdust. The brine is kept at the boiling point by means of a series of 3 $\frac{1}{2}$ " pipes, which run the full length of the tank, just above the conveyer, and which are supplied with live steam. A small shallow pan 40 ft. $\times$ 26 ft., supplied with 2" pipes, utilizes the exhaust steam from the tank and in this a coarse grade of salt is made. Both pans are emptied every three weeks, and the pipes and sides of the pans freed from the accumulation of gypsum which has been deposited. Operations are then resumed, with fresh brine.

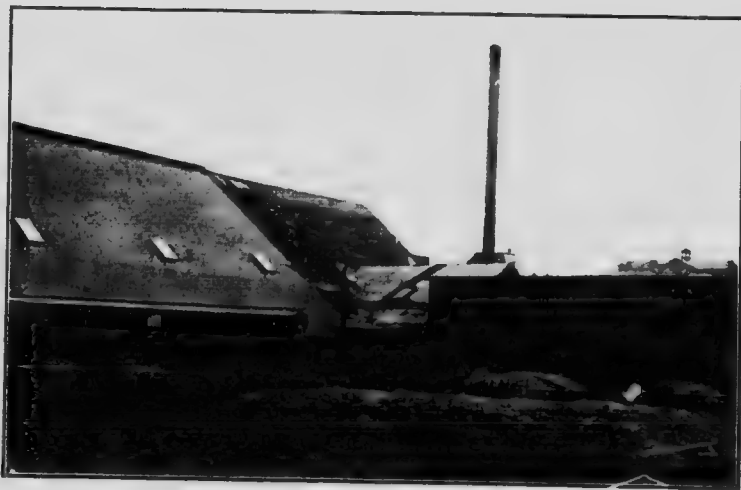
The salt is drawn from the hopper bin, dried and packed into barrels of 280 pounds capacity. See Plate III A.

The capacity of the plant is about 125 to 150 barrels of fine salt, and 1 $\frac{1}{2}$ tons of coarse salt every twenty-four hours.

The power plant of this Company consists of three tubular boilers, having a total capacity of 300 horse power. A Goldie-



A. Shipping wharf, Ontario People's Salt and Soda Co., Kincardine, Ont.



B. Ontario People's Salt and Soda Co. plant, showing railway facilities, Kincardine, Ont.

PLATE III.



A. Packing shed, Ontario People's Salt and Soda Co., Kincardine, Ont.



B. Plant of Dominion Salt Co., Sarnia, Ont.

McCullough, slide valve, single cylinder engine of 125 H.P., is employed to operate the conveyer, elevator, pumps, etc.

An endeavour was made some 25 years ago to establish an electrolytic soda plant at these works; but the attempt, for some reason, was abandoned.

GREY, YOUNG AND SPARLING CO., OF ONTARIO, LIMITED.

Locality: Wingham, Ont.

Transportation facilities: The salt is conveyed in barrels, by teams, to the stations of the Grand Trunk, and Canadian Pacific railways; both roads entering Wingham.

The brine used by this Company is obtained from a well 1,185 feet deep, with 30 feet of salt. The well is situated 2 miles from the works, and the brine has to be pumped and piped that distance. At the works there is a storage tank 20 ft. $\times$ 30 ft. $\times$ 7 ft. deep, from which the brine is run by gravity into open pans. These pans are two in number, 24 ft. $\times$ 70 ft., but only one is operated at a time. Coal is used as fuel for the fires under the pans. The salt is scraped from the pans by means of rakes, allowed to dry, and then is incased in barrels made on the premises. Work is carried on for six days in the week, and the fires are allowed to die out on Sunday. The coarse salt resulting from the slow evaporation at the week end, is called, locally, Sunday Salt. The capacity of the plant is about 100 barrels per day; but is only operated at this capacity during part of the year. Nearly all the product is consumed locally.

STAPLETON SALT WORKS.

(J. Ransford, operator.)

Locality: The works are located on the road between Clinton and Stapleton, about $1\frac{1}{2}$ miles east of the former place.

Transportation Facilities: The salt is hauled by teams to the Grand Trunk Railway at Clinton. A view of the settling tanks is shown in Plate I B.

At this plant, one well, 1,300 feet deep, supplies the brine which is evaporated by the open pan method. Two pans are employed, placed end to end, the fireplaces having a common stack at the centre. The capacity of the works is 30 tons of fine salt per twenty-four hours. Twenty men are employed. The salt is marketed under the brand of "The Stapleton Salt Works." The drying bins are shown in Plate VI A.

NORTH AMERICAN CHEMICAL CO.

(J. Ransford, operator.)

Locality: Goderich, Ontario. (See Plate I A.)

Transportation facilities: Grand Trunk, and Canadian Pacific railways.

There is one well at this plant, 1,200 feet deep, which passed through the first bed of salt. This well has been in operation since 1880. No water has to be forced down this well, which, in common with many others in the northern part of the salt basin, encounters a water fissure in the first few hundred feet, and this supplies sufficient water to form all the brine pumped.

The brine is pumped into two settling tanks, 16 ft. $\times$ 20 ft. $\times$ 5 ft., from which it flows by gravity to the pan operated by the open pan method. This pan is 100 feet long, and 30 feet wide. The capacity of the plant is 18 tons of fine and 2 tons of coarse salt every twenty-four hours, ten men being employed. This salt is marketed all over Ontario, under the brand of "Rices Pure Salt."

WESTERN CANADA FLOUR MILLS CO., LIMITED.

Locality: Goderich, Ont.

Transportation facilities: Siding from Grand Trunk Railway station to works; also wharfage on Lake Huron.

The brine used at this Company's plant is obtained from a well 1,150 feet deep. Two open pans are in use, and are heated by exhaust steam from the flour mill. This steam passes through a steam chamber underneath the pans. The brine is heated

before being run into the pans. Only coarse salt is made. This is shipped in bulk or in sacks by rail to Ontario points.

Twenty-four tons are made in twenty-four hours; an average of six men being employed.

EXETER SALT CO.

Locality: Exeter, Ont.

Transportation facilities: Beside the tracks of the Grand Trunk railway.

One well, 1,225 feet deep, is operated by this Company. The brine is pumped into a settling tank 20 ft. $\times$ 25 ft. $\times$ 36 ft. This pan is divided into sections by partitions, the brine flowing from one to the other. By this means the different grades are kept separate. The trade is mostly local; and the plant is operated only three or four months each year. Six men are employed.

PARKHILL SALT CO.

Locality: Parkhill, Ont.

Transportation facilities: Grand Trunk railway.

The well of this Company is 1,300 feet deep, and the brine is treated by the open pan method, in one pan 100 ft. $\times$ 24 ft., beneath which are three fire places. Both wood and coal are used for fuel. The works are kept running day and night seven in operation; but the plant is only operated for about while weeks each year. The pan has to be cleaned every week, due to gypsum forming as a crustation. Only coarse salt is produced, which is all consumed locally. The capacity is about 100 barrels per 24 hours.

ELARTON SALT CO.

Locality: Lot 6, Con. III, South Egremont Road, Warwick.

Transportation facilities: The salt is hauled to the Grand Trunk railway, at Kingscourt.

The brine at this plant is obtained from a well 1,460 feet deep, and the salt is 130 feet thick, with partings of shale. The open

pan method is in use. The pan is 60 feet long by 20 feet wide, and wood fuel is used. The plant is in operation only seven weeks each year; the product being disposed of locally.

THE DOMINION SALT COMPANY LIMITED.

Locality: Sarnia, Ont.

Transportation facilities: The works are connected with the Grand Trunk railway by a siding; water shipment is also available, as the works are situated on the shore of the St. Clair river. See Plate III B.

This company has three wells from which it obtains its brine, the deepest of which is 2,115 feet. The following flow-sheet (Fig. 2) shows the operations as carried on at this plant.

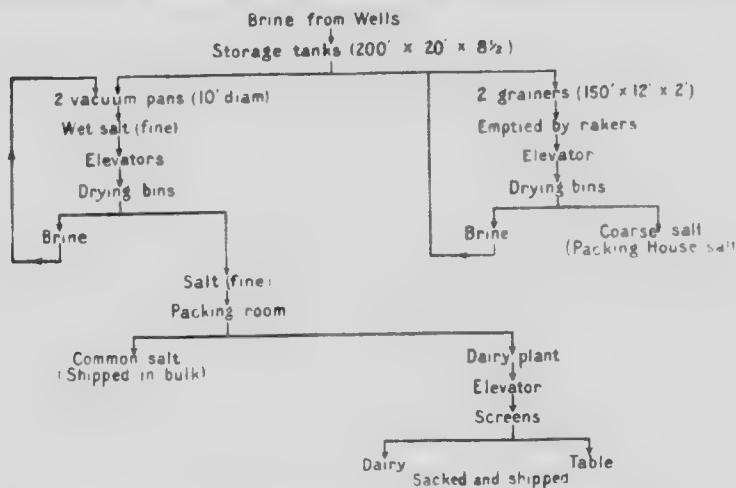


Fig. 2. Flow sheet, Dominion Salt Company's plant, Sarnia, Ont.

The plant uses exhaust steam during the day, and live steam at night, obtained from the Cleveland Sarnia Lumber Company. River water is pumped down the wells to dissolve the salt. The plant, when running full capacity, can produce 1,200 barrels per day. An average of thirty-five men are employed.

THE WESTERN SALT COMPANY.

Locality: Courtright, Ont.

Transportation facilities: Père Marquette railway, and water shipment from wharf beside company's property.

This Company operates one well of a depth of 1,700 feet. The open pan method is used in one plant. A second plant has been recently erected, in which vacuum pans and grainers are employed, and this plant is now in operation.

In the open pan plant the pan is 100 ft. $\times$ 20 ft. wide. Coal is used as fuel. The pans are raked out by hand every hour, and, after being drained, the salt is loaded into bins, and from these it is elevated to the top floor, where it goes through a revolving drum. The flow-sheet of this plant is shown in Fig. 3.

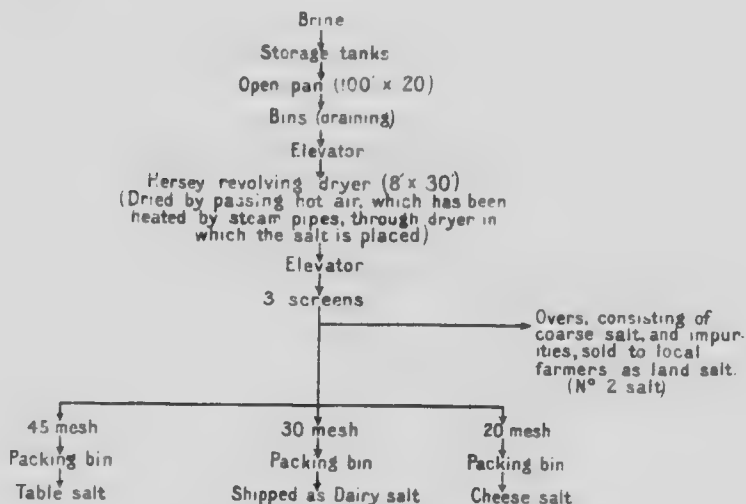


Fig. 3. Flow sheet, Western Salt Company's plant, Mooretown, Ont.

The different grades are packed: the coarser in barrels and bags; the table salt in 3, 5, 7, 10, 20, and 50 pound bags, and the dairy and cheese grades, in 50 and 200 pound bags, and also barrels. The Company has a large trade with the Canadian west.

THE CANADIAN SALT CO.

(Windsor Plant).

Locality: Windsor, Ont.

Transportation facilities: The works are situated close to the tracks of the Canadian Pacific railway, near Windsor. Connections are also made with the Grand Trunk, and the Michigan Central railways. The Company has built a wharf on the Detroit river, which enables shipments of all its products to be made by boat to all lake points.

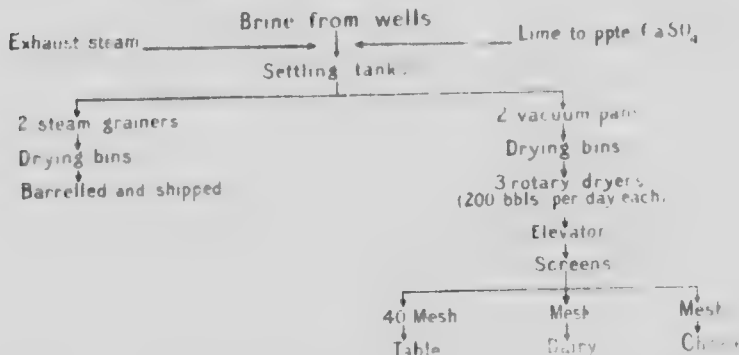


Fig. 4. Flow sheet, Canadian Salt Company's plant, Windsor, Ontario.

Five wells are being operated at this plant, their depths ranging from 1,167 to 1,700 feet. Water is forced down the casing, and brine pumped up the inner pipe. Compressed air is used for pumping, in the manner described in Chapter IX.

The brine coming from these wells flows into settling tanks, in which it is treated with a small quantity of lime, and heated with exhaust steam. The accompanying flow-sheet (Fig. 4) shows the operations as carried on at this plant.

The plant is run by the exhaust steam from the plant of the Windsor Electric Street Railway—with the addition of some live steam.

PLATE IV.



Plant of Canadian Salt Co., Windsor, Ont.

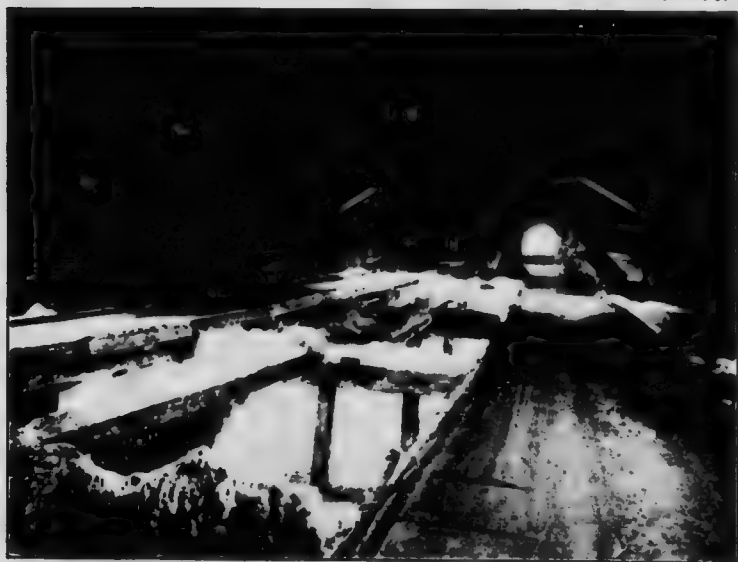


A. Power house, Canadian Salt Co., Windsor, Ont.

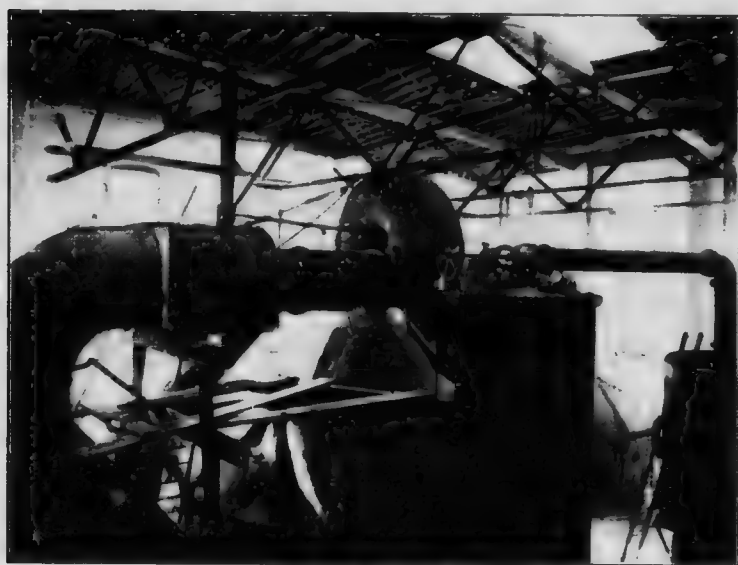


B. Boiler room, Canadian Salt Co., Windsor, Ont.
(Boilers fired by natural gas.)

PLATE VI.



A. Drying bins, Stapleton Salt Works, Clinton, Ont.



B. Vacuum pans, Canadian Salt Co., Windsor, Ont.

PLATE VII.



A. Drying bins, Canadian Salt Co., Windsor, Ont.



B. Packing room for coarse salt, Canadian Salt Co., Windsor, Ont.

PLATE VIII.



A. Automatic bagging machine and bag sewer, Canadian Salt Co., Windsor, Ont.



B. Automatic bagging machines, Canadian Salt Co., Windsor, Ont.

The main building, containing the vacuum pans and the principal machinery, measures 60×40 feet, and is 70 feet in height. The packing and storage house measures 200 feet $\times$ 120 feet. There is also a cooper's shop, having a capacity of 1,000 barrels per day, in which all barrels are made; besides several other buildings. Four new steel settling tanks have lately been erected, 130 feet long $\times$ 15 feet wide, $\times$ 8 feet deep, with $\frac{5}{16}$ " bottom, and $\frac{1}{4}$ " sides.

The salt is weighed and bagged by automatic weighing and bagging machines. The salt is packed in bags and barrels. A special brand of free-flowing salt is now being put up in cylindrical cartons.

The output of the plant is 1,200 barrels per day—the capacity, however, is much greater. Employment is given to 120 persons.

The products from this plant are well known all over Canada as "Windsor Salt." Plates IV; V, A & B; VI, B; A & B, and VIII, A & B, show different views in and around this plant.

CANADIAN SALT COMPANY.

Chemical Branch, Sandwich, Ont.

The only company which at the present time is actively engaged in the production of any of the chemical products from sodium chloride is the Chemical Branch of the Canadian Salt Co., at Sandwich, Ont. Since the autumn of 1911 this Company has been carrying on the manufacture of both caustic soda and bleaching powder, from the salt in the brine obtained from their wells in that town.

Here, the Company has a well equipped plant, employing the electrolytic process for the decomposition of the brine into Cl and Na. The plant consists of the following buildings and structures¹:—

¹The salt-making plant at this place is mentioned separately, so its buildings are not included in this list.

3 brine wells.
 3 settling tanks.
 Concrete-block building.
 Boilers. Electric power plant. Cell room. Vacuum room. Caustic pot room.
 Concrete-block building.
 Lime hydrating room.
 Bleaching chambers.
 Office,
 Other buildings.

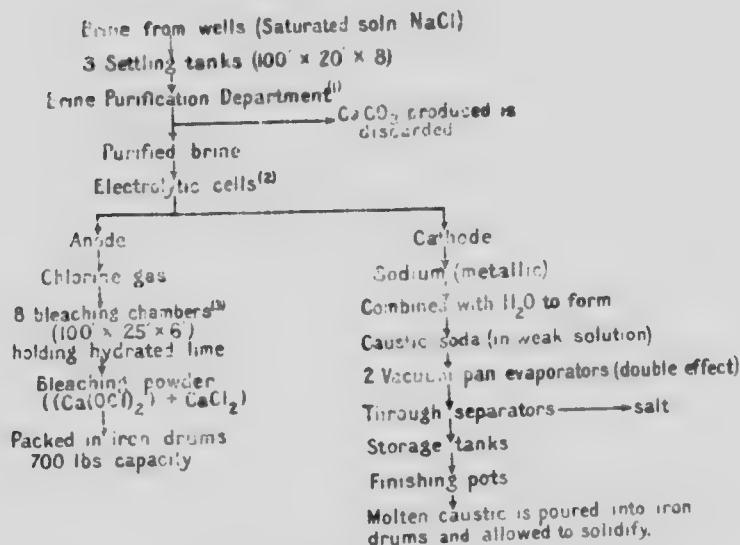


Fig. 5. Flow sheet, Canadian Salt Company, Chemical Branch, Sandwich, Ontario.

NOTES:—(1) Brine is treated by the addition of soda ash (Na_2CO_3) dissolved in hot water, in order to eliminate the lime. Carried on in six concrete tanks of 30 tons each; (2) Hibb patent, 256 cells arranged in rows; (3) These chambers are lined throughout with lead, and the pipes in the bottom covered with cement.

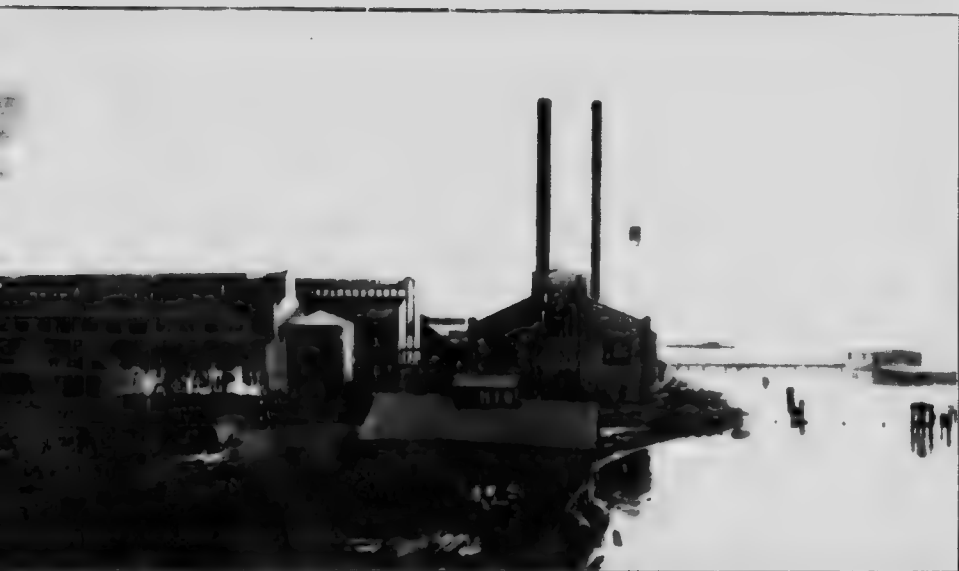
Shipping facilities are good, as the C. P. R. has a siding directly to the plant, and, as the plant is situated on the bank of the Detroit river, both water and rail transportation are convenient. See Plates IX and X, A and B.





Plant of Canadian Salt Co., (Che

PLATE IX.

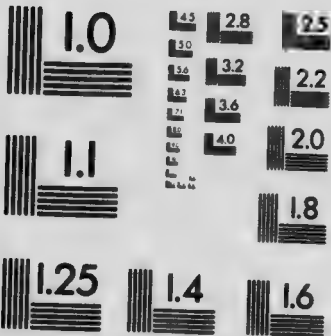


Co., (Chemical Branch) Sandwich, Ont.



MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc

1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 286 - 5989 - Fax



A. Bleaching chambers building (in course of construction), Canadian Salt Co., Chemical Branch, Sandwich, Ont.



B. Bleaching chambers building (in operation), Canadian Salt Co., Chemical Branch, Sandwich, Ont.

Flow sheet (Fig. 5), illustrates the system adopted at this plant for the production of caustic soda and bleaching powder.

The power plant consists of:—

1—550 KW. generator, Canadian Westinghouse, (2,500 Amps.).

1—600 KW. generator.

Generators run by 27" × 42" direct connected, Goldie and McCulloch engine, operated at a speed of 100 r.p.m.

Boiler plant of 1,200 H.P. (Tubular horizontal boilers).

Hydrating plant—Harris hydrator.

The brine coming from the wells—which are from 1,600 to 1,800 feet in depth—derives its salt from beds which vary from 2 to 14 feet in thickness. The brine is pumped directly into settling tanks, and from there it is carried to six concrete tanks, in which it is treated by soda ash in order to eliminate the lime which is present in small quantities. The soda ash is dissolved in hot water before adding to the brine. The purified brine is then treated in electrolytic cells, where the sodium chloride is decomposed into chlorine gas and metallic sodium. The metallic sodium at once reacts with the water, forming caustic soda. There are 256 of these cells, arranged in 8 rows, with 32 in each row. These cells employ direct current at 220 volts.

The cell employed at this plant is a modified form of the Gibb Cell, as patented by A. E. Gibb on March 31, 1908, under patent No. 110604. Fig. No. 6 is taken from the patent specification. In this drawing, fig. 1 is a cross-section of the complete cell; fig. 2 a cross-section of the diaphragm; figs. 3 and 4, two sections of diaphragm and cathode, showing corrugated cathode; fig. 5, carbon anode bar, and fig. 6, perforated cathode.

This cell is of the diaphragm type mentioned in Chapter X.

The construction of the cell is simple, and consists of a cast steel shell(2), in which the cathode and anode are placed. The diaphragm (8) is composed of asbestos or any other permeable substance which is not attacked by the liquids. It is preferably formed with walls which gradually decrease in thickness from the bottom towards the top, so that the difference in permeability shall substantially correspond to the difference in hydrostatic

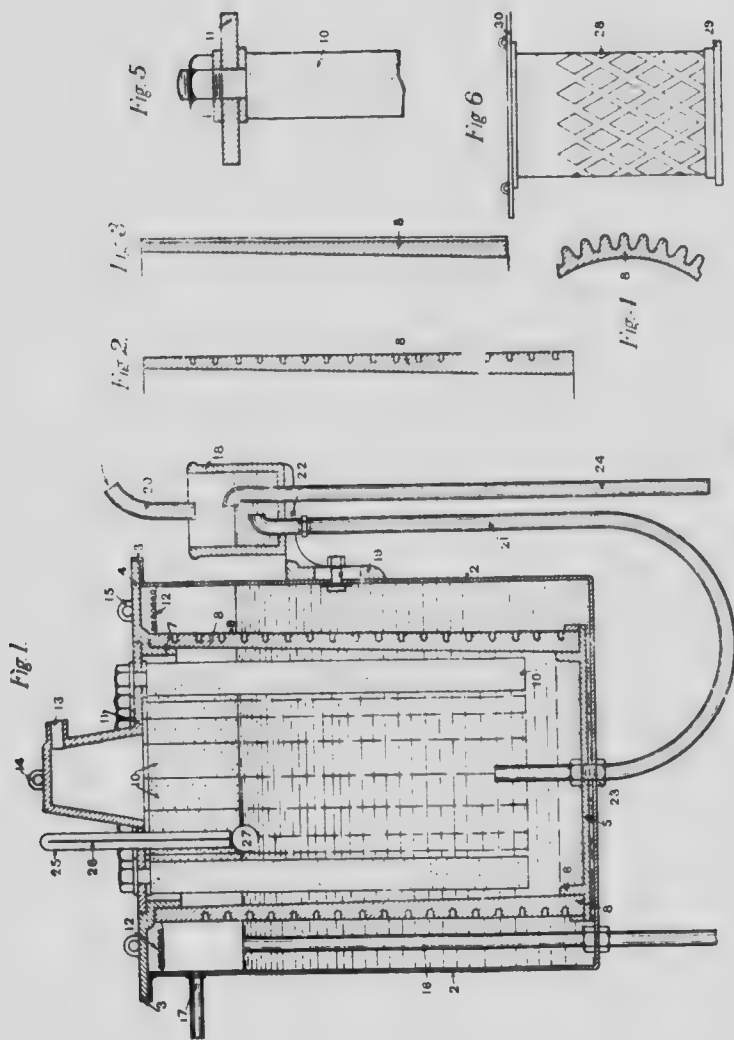


Fig. 6. Gibb electrolytic cell.

pressures between the top and bottom of the solution in the cell. The cathode is made in several different ways. It essentially consists of a metal jacket placed around the diaphragm with a number of inner points or projections facing and imbedded in the diaphragm. The cathode may be either perforated, as shown in fig. 6 in drawing, or may be corrugated, see figs. 3 and 4 in drawing. This enables the products of electrolysis to be forced into the cathode chamber, and thus out of the sphere of electrolytic action. The anode is made up of a number of carbon rods arranged in annular form and projecting through the dome (11), which rests upon an annular recess in the ring (4).

The positive (+) wires lead to these anodes, while the negative (-) wires lead from the cell jacket, to which the cathode is connected, by a series of suitable connexions (12) extending through the cathode compartment.

There is a gas outlet in the dome.

The advantages claimed by Mr. A. E. Gibb, the inventor, for his cell, are as follows¹:—

The advantages of my invention result particularly from the cathode having points or projections entering the diaphragm. Also from the use of offtake channels for the products in connection with these embedded points or projections. The adjustable cup enables me to adjust the flow to give the best efficiency, and this will, of course, vary to some extent during the life of the cell. By embedding the point or projections of the cathode in the diaphragm, I produce electrolytic action at separated points and places while allowing the products to pass immediately into an inactive region. By using this peculiar diaphragm and jacket cathode with embedded points, I can maintain substantially the same permeability for an indefinite period. With an ordinary diaphragm its filtering action will cause its permeability to gradually decrease owing to clogging, but I find that my diaphragm builds up to some extent on the inner side while it disintegrates to some extent on the outer side owing to the gas evolved at the points or projections. This double action goes on substantially, continuously and keeps the permeability approximately constant. This is of great importance as it enables the operation to be carried on with little attention and consequently one operator can attend to a very large number of cells.

This improved cathode also prevents the destructive effect of the small percentage of hypo-chlorite which is present in the final liquor of ordinary cells. The intimate contact between the liquor coming from the anode compartment and the cathode points insures a complete action of the nascent hydrogen at such points, thus effectively destroying all hypo-chlorite.

The weak solution of caustic soda thus produced in these cells is concentrated in two vacuum pan evaporators, operated

¹Extracts from Patent Specification—Pat. No. 110604, Canada.

double effect. The solution is taken from these to storage tanks—after being passed through separators—to eliminate the salt. The final concentration is carried on in the finishing pots, and the pure caustic soda is run from the final pot into iron drums (700 lbs. capacity), and allowed to solidify. The finishing pots have a capacity of 18 tons each. They are made of cast iron, 10 feet in diameter, and 6 feet deep. The setting is built of fire brick.

The chlorine gas, previously referred to as being generated in the cells, is piped to the bleaching chamber building, where it is allowed to circulate through eight bleaching chambers. These chambers are 20 ft. wide and 100 ft. long, and are lined on sides and roof with chemical lead. On the bottom are laid 2" cooling pipes, firmly secured by a covering of cement, over which is laid a layer of asphalt. This arrangement thoroughly protects the pipes from the gas. On top of the asphalt is laid a layer of hydrated lime 3" thick. The chlorine gas circulating through the chambers reacts with this lime, forming bleaching powder, which, when ready, is drawn off through openings in the bottom of each chamber. The shipping floor is situated beneath the chambers. The bleaching powder is packed in drums of 700 pounds capacity.

The cooling pipes are connected with an ammonia refrigerating plant.

The percentage of bleach in the chloride of lime produced at this plant will vary from 37 per cent to 39 per cent, i.e., this bleach contains from 37 per cent to 39 per cent chlorine that is available for bleaching purposes.

The whole product from this plant finds a ready market in Canada.

CANADIAN SALT COMPANY, SANDWICH, SALT PLANT.

The Canadian Salt Company has, at its Sandwich branch, a salt block in which it makes medium, fine, and coarse salt. The brine is pumped from the wells to settling tanks, and there heated and treated with lime, before being carried to six grainers. These grainers are 150 feet long by 12 feet wide, and are equip-

ped with automatic chain rakers. The salt produced in these grainers is taken by carts to the drying and packing bins. The final products are shipped in ordinary bags and barrels.

In connexion with the Alkali industry, the following item taken from "The Iron Trade Review," is of interest.

CANADIAN ALKALI CO., SANDWICH.¹

The province of Ontario has granted a charter to the Canadian Alkali Co. Ltd., for the establishment of a plant at Sandwich, Ont., and as soon as practicable, work will be started on a site in close proximity to the land of the proposed new plant of the United States Steel Corporation. The Canadian Alkali Co. Ltd., is to have a capital stock of \$2,000,000. With one exception the men heading the new industry are Detroit capitalists, the officers being: President, Jas. Inglis; vice-president, William McBain, of Toronto; Treasurer, M. G. Borgman, and secretary and general manager, H. S. Dodson. These with A. L. Stephens form the board of directors.

The company has acquired a large acreage and will develop immense salt beds which are said to underlie its property and scientifically treat the products by a chemical process patented by Howard M. Dubois, a chemical engineer of experience. The products will include sodium chloride or chemically pure salt, caustic soda or lye, and chloride of lime. Mr. Dubois was formerly associated with the Wyandotte plant of the Pennsylvania Salt Co. The Company will open offices in Windsor and in Detroit and all of its buildings will be of the latest form of construction representing what is known as the daylight type.

The following eight analyses were made by Mr. F. G. Wait—chief chemist, Mines Branch,—of brine samples taken by the writer, during the field season of 1911.

¹The Iron Trade Review, 27, 1913, p. 498.

Report of analyses, of eight sam

1,000 parts by weight, contain:

1

Na.....	96.2
Ca.....	1.5
Mg.....	.2
SO ₄	2.6
Cl.....	150.1
	250.6

Hypothetical combination: 1,000 par

Na. Cl.....	244.8
Ca. Cl.....	1.4
Mg. Cl.....	.1
Ca. SO ₄	3.3
	250.6

Total solids dried at 180°C. direct	
Expt.	257.
Spec. gravity at 15.5°C. by hydro-	
meter.....	1.

One imperial gallon, measured at 15

Na. Cl.....	2.
Ca. Cl.....	.
Mg. Cl.....	.
Ca. SO ₄	.
	3

Locality of occurrence of ab

1. Western Canada Flour Mil
2. American Chemical Co.'s w
3. Stapleton Salt Works, Clin
4. Ontario People's Salt and S
5. Sparling Co., Wingham, O
6. Western Salt Co., Mooreto
7. Dominion Salt Co., Sarnia.
8. Dominion Salt Co., Sarnia

Ottawa, November 10th, 1911.

TABLE III

BRINKLE

Report of analyses, of eight samples collected by Mr. L. H. Cole, at the undermentioned localities.

1,000 parts by weight, contain

	1	2	3	4	5	6	7	8
Na	96.270	99.512	103.744	101.738	103.764	102.513	96.368	100.997
Ca	1.552	1.571	1.491	1.630	1.332	1.386	2.196	1.531
Mg	.244	.135	.476	.257	.515	.075	.127	.118
SO ₄	2.631	2.850	1.946	2.631	2.780	3.160	1.698	2.809
Cl	150.122	154.675	164.291	158.742	161.987	158.56	152.294	164.84
	250.819	258.743	272.951	265.001	270.378	265.696	252.983	262.336

Hypothetical combination: 1,000 parts by weight contain:—

Na. Cl	244.860	253.105	266.415	258.770	263.921	260.812	245.111	256.891
Ca. Cl ₂	1.265	1.066	1.895	1.484	.477	.111	4.964	1.007
Mg. Cl ₂	.966	.534	1.884	1.017	2.040	.297	.503	.467
Ca. SO ₄	3.728	4.037	2.757	3.730	3.939	4.476	2.105	3.971
	250.819	258.742	272.951	265.001	270.377	265.696	252.983	262.336
Total solids dried at 180°C. direct								
Expt.	257.700	259.813	268.404	264.673	269.113	264.243	248.112	258.257
Spec. gravity at 15.5°C. by hydro-								
meter	1.197	1.200	1.2035	1.2045	1.2005	1.2065	1.178	1.198

One imperial gallon, measured at 15.5°C. contains:—lbs. avoird.

Na. Cl	2.931	3.037	3.197	3.105	3.16	3.156	2.887	3.083
Ca. Cl ₂	.015	.014	.023	.018	.008	.001	.058	.012
Mg. Cl ₂	.011	.006	.023	.012	.021	.004	.006	.006
Ca. SO ₄	.045	.048	.033	.045	.047	.054	.028	.048
	3.002	3.105	3.276	3.180	3.244	3.215	2.979	3.149

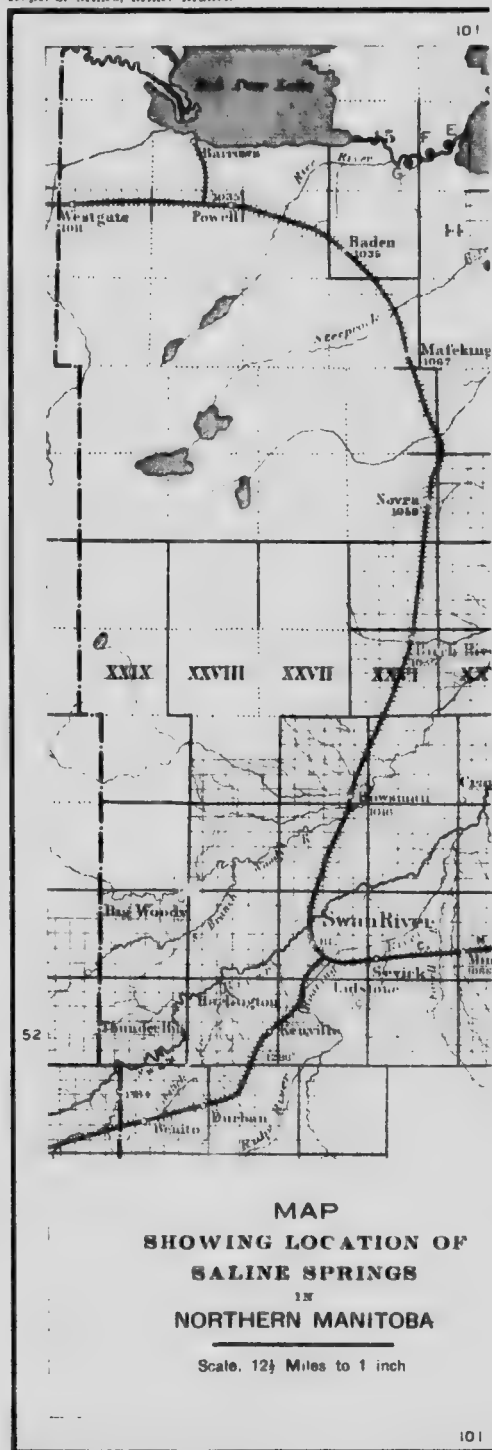
Locality of occurrence of above samples:—

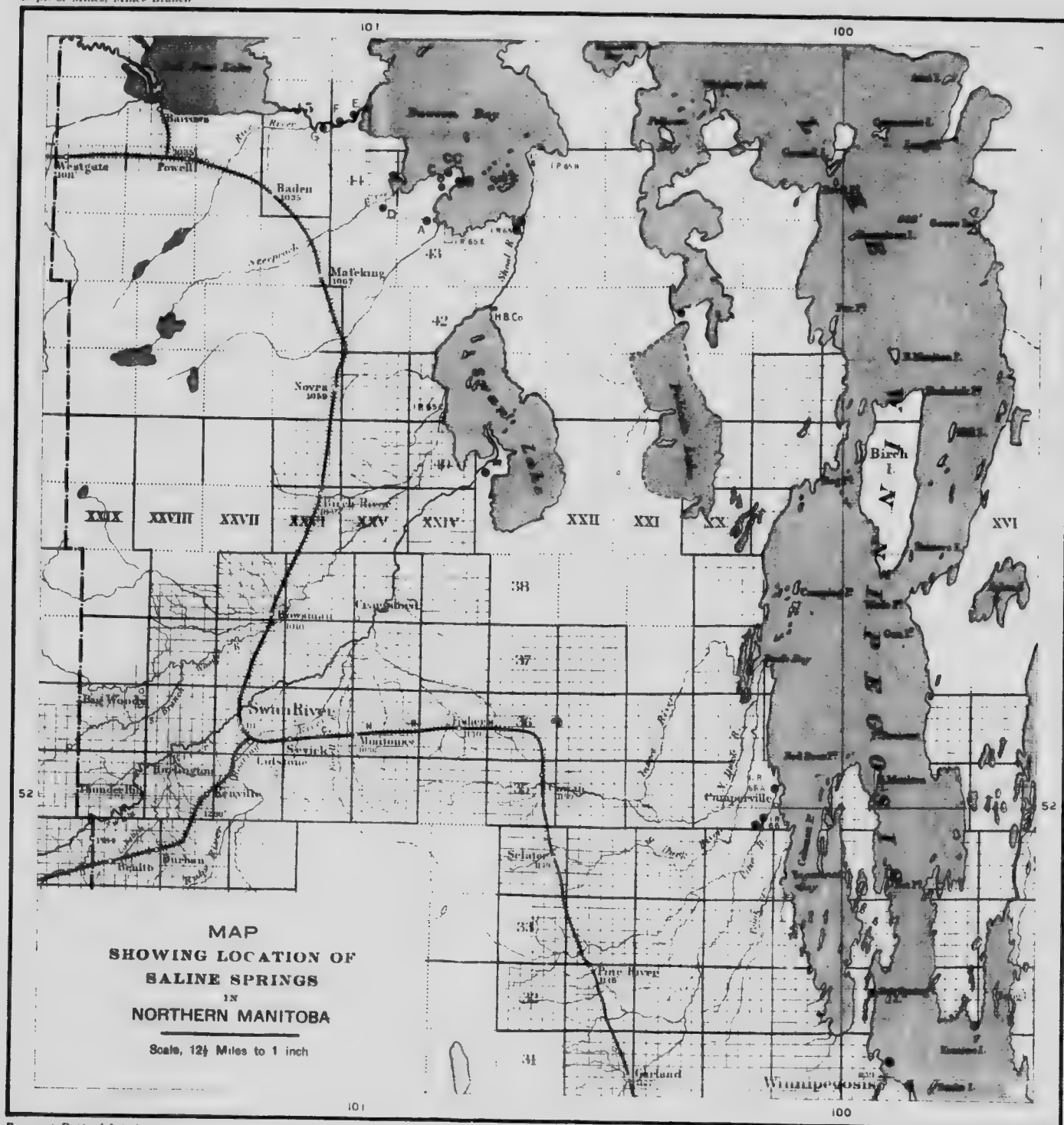
1. Western Canada Flour Mills well, Goderich, Ont., taken July 5th, 1911.
2. American Chemical Co.'s well, Goderich, Ontario, taken July 5th, 1911.
3. Stapleton Salt Works, Clinton, Ontario taken July 6th, 1911.
4. Ontario People's Salt and Soda Co., Kincardine, Ont., taken July 8th, 1911.
5. Sparling Co., Wingham, Ont., taken July 7th, 1911.
6. Western Salt Co., Mooretown, Ont., taken July 14th, 1911.
7. Dominion Salt Co., Sarnia, old well, taken July 12th, 1911.
8. Dominion Salt Co., Sarnia, new well, taken July 12th, 1911.

Ottawa, November 10th, 1911.

(Signed) F. G. WAIT.







CHAPTER V.

SALT IN MANITOBA.

INTRODUCTION.

Beds of rock salt have not, as yet, been discovered in the Province of Manitoba, but numerous brine springs are known, and from these, in past years, salt has been recovered by evaporation. When first these springs became known, the area in which they occurred seemed to be limited to the district lying to the west of Lake Winnipegosis, and this still remains the only district in which natural flowing springs occur. Of late years, however, in drilling operations in the vicinity of the city of Winnipeg and the district to the west as far as the boundary line between Saskatchewan and Manitoba, brines have been encountered in numerous holes and wells. Further drilling will most likely demonstrate a considerably larger area under which brine waters may be found.

The source of the salts found in these brines is at the present time, not definitely known. According to Mr. J. B. Tyrrell, who visited the Winnipegosis springs in 1889, the salt is obtained by the leaching of numerous salt crystals which occur in the porous dolomites of the district. He states¹:—

The presence of brine springs is a well marked feature of the Devonian area west of Lakes Winnipegosis and Manitoba; but while the most copious supply of brine flows from the Devonian rocks, chiefly marking the base of the Upper Devonian, salt is not absent from the beds of Silurian age, and many slabs of this rock were found showing beautiful moulds of typical crystals of chloride of sodium. A few small springs of clear salty water were found flowing from the Silurian area on the west side of Winnipegosis. Careful search was made everywhere for indications of the presence of beds of pure salt, but none were found, and instead, impressions of salt crystals were common in all the more porous dolomites. It is possible therefore, that the salt occurs entirely in more or less isolated crystals scattered throughout the rock, but in some cases these are so numerous that at least a third of the whole mass has been salt.

According to this theory, salt crystals are found in rocks of late Silurian or early Devonian age; and, judging from the

¹Annual Report, Vol. V, Pt. I, p. 219E, Geol. Survey of Canada.

amount of flow from the springs of the district, and their saline content, the crystals of salt would have to form a considerable portion of the dolomitic beds of the district.

A second possible theory of the source of these brines is, that they come from residual, original, sea water. This theory has been put forward by several to account for some of the brines found in the formations above the Salina in Michigan. It is conceivable that, a sudden change in the character of deposition in a closed-in basin, from a coarse to fine material, might readily imprison any residual sea water held in the voids of the coarser material already laid down. In this case, the brines would have more or less the composition of a bittern; unless the change occurred very early in the stage of deposition.

A third theory, and one that seems most probable, is that the brines derive their salts from the leaching out by meteoric waters of a salt bed laid down in either Devonian or Silurian age. Immediately to the west of the district in which the flowing saline springs occur, Porcupine mountain, having an approximate catchment area of 1,200 square miles, rises to an average elevation of 1,500 feet above the country directly to the east of it. The underground drainage from this area would be sufficient to furnish a constant source of fresh water to supply the necessary solvent required for dissolving the rock salt. The high calcium sulphate content in all of the brines analyzed would lead one to believe that the source of the salt is intimately associated with gypsum.

The data available, however, at the present time, are not sufficient to give preference to any special one of the three theories above stated. Dr. R. C. Wallace, of the Department of Geology, University of Manitoba, is, during the present summer, (1914) making an extensive examination of the district for the Geological Survey, with a view to ascertaining the probable origin of these saline springs as well as the origin of the gypsum deposits of the district in the vicinity of Lake St. Martin. His report, which will be published next winter as a bulletin of the Geological Survey of Canada, will deal fully with the geology of the district.

EARLY HISTORY.

For a complete record of the early history of the discovery of salt and its manufacture from the brine springs of Manitoba, an extensive search would have to be made through the past records of the Hudson Bay Company.

To the Indians of the Plains, the springs must have been known for many years, and use made of them for domestic needs. In the early years of the nineteenth century—about the year 1820, at the brine springs situated on Red Deer Peninsula in the southern part of Lake Winnipegosis, active operations were commenced by James Monkman in the manufacture of salt. The production then obtained was small, and the product only used for local demands. When these springs were visited in 1858, by Prof. H. Y. Hind, operations were being conducted by James Monkman's sons, on a more extensive scale, and with some degree of profit; as the salt was in greater demand owing to the influx of settlers in the neighbourhood of the Red River valley. In his report¹, Prof. Hind gives the following description of these "Monkman Salt Works" as they then existed:—

The soil at the Salt Springs is a very retentive yellowish white clay, containing small limestone boulders and pebbles, with boulders of unfossiliferous rocks. The wells, for obtaining a supply of brine, are sunk wherever a small bubbling spring is observed to issue from this retentive clay. The springs are constantly changing their position, and as the wells become exhausted from time to time, a fresh excavation is made where a new spring is observed to issue. No doubt boring, or deeper wells, would prevent these changes, and not only secure a larger flow of brine, but insure its permanency. The wells at present are twenty-five in number; but some of them appear to have been lately abandoned, and others have long since ceased to yield brine. They are situated 400 yards from the lake shore, and were first worked 40 years since by James Monkman. This enterprising individual, struggled for many years against the importation of English salt, which was sold in the settlements at a cheaper rate than he could afford to manufacture salt on Lake Winnipegosis. He has made salt at Swan river and Duck river. The manufacture is now carried on with profit for the Hudson Bay Company, at Swan river, and at Winnipegosis lake by Monkman's sons.

At the Works there are two small log houses and three evaporating furnaces. The kettles, of English construction, are well made rectangular vessels of iron, five feet long, two feet broad and one foot deep. They are laid upon two rough stone walls, about twenty inches apart, which form the furnace. At one extremity is a low chimney. The whole construction is of the rudest description; and at the close of the season the kettles are removed, turned over, and the furnace permitted to go to ruin, to be rebuilt the following spring.

¹Report on Assiniboine and Saskatchewan Exploring Expedition, by H. Y. Hind, 4to., Toronto, 1859, pp. 94-95.

The process of making salt is as follows: When a spring is found, a well, five feet broad and five feet deep, is excavated, and near it an evaporating furnace erected. The brine from the well is ladled into the kettles, and the salt scooped out as it forms, and allowed to remain for a short time to drain before it is packed in birch bark roggins for transportation to Red river, where it commands twelve shillings sterling a bushel, or one hundred weight of flour, or a corresponding quantity of fish, pemican, or buffalo meat, according to circumstances.

The brine is very strong. From one kettle two bushels of salt can be made in one day in dry weather. There are nine kettles at the 'Works,' seven being in constant use during the summer season. The half-breeds engaged in the manufacture complained of the want of fuel—in other words, of the labour and trouble of cutting down the spruce and poplar near at hand, and the difficulty of hauling it to the furnaces. An objection of no moment, but characteristic of some of the people, who are generally unaccustomed to long-continued manual labour. Unfortunately I had no instrument with me, for ascertaining the specific gravity of the brine, and a supply which I took to Red River for that purpose, as well as with a view to its analysis, still remains in the settlements. It will be seen that the processes employed in the manufacture of salt are of the rudest description, so that without any outlay beyond a few days' labour, the quantity might be largely increased. I spoke to John Monkman, who now makes salt here, of pumps and solar evaporation. Of a pump he knew absolutely nothing. He had heard that such an apparatus had been contrived, but had never seen one. He readily comprehended the advantage to be derived from pumping the water into shallow troughs, dug in the retentive clay near the springs, and strengthening the brine by solar evaporation."

Mr. T. W. Spencer, who, during the summer of 1874, made a brief exploratory trip into the region where these brine springs occur, found that the manufacture of salt was still being carried on, in a small way, at the springs at the south end of Lake Winnipegosis: presumably the same springs where the Monkmans carried on operations. He gives the following description of the operations as carried on at the time of his visit¹:—

The salt springs at the south end of Lake Winnipegosis have been worked for a long time. At these springs the saline waters percolate through the drift, which in this region covers but thinly the Devonian limestones, and destroys vegetation for some distance around. The manufacture of the salt is conducted in a rude manner. Pits are dug four or five feet deep, and into them the waters infiltrate. Beside these temporary furnaces are erected, on which are placed evaporating pans made of iron plate one-eighth of an inch thick and five or six feet long, by about three feet wide and eight or ten inches deep. Beside the pans, are trays on which the salt is raked. No pumps are used, the water being lifted directly from the pits by means of pails. The operation is conducted entirely in the open air. The manufactured salt is put into birch-bark boxes, or "mococks," holding about 100 pounds each, and is then ready for market. During the season Mr. McKay the only person engaged in the business, made about 500 bushels, or less than half the quantity which had been manufactured in some previous years.

¹Report of Progress for 1874-75, Geol. Sur., Can., p. 69.

Mr. Spencer made the following analysis of a sample of the salt which he brought from the works:—

Sodium chloride.....	95·123	per cent.
Magnesium chloride.....	0·600	"
Calcium sulphate.....	3·400	"
Sodium sulphate.....	0·394	"
Moisture.....	0·044	"
Residue.....	0·439	"
	100·000	

The residue, he found to consist of silica, alumina, iron and lime. The salt had a light brown tint, and was very coarse grained.

From the time of Mr. Spencer's visit in 1874, the manufacture of salt from these springs seems to have gradually waned, so that when they were visited in 1889 by Mr. J. B. Tyrrell—then of the Geological Survey—there was no salt being manufactured, save, perhaps, for a small production made from time to time by wandering Indian families for their own use. This falling off, and final abandonment of all operations is readily understood, since the advent of the railway into Manitoba made the better and more cheaply produced salt of the Ontario and Michigan districts available at a price which negated competition at that time.

Since 1890, attempts to manufacture salt on a commercially profitable scale have been made locally, but with little success, and now, operations have been entirely abandoned.

SALINE SPRINGS.

As already stated, saline springs occur, and numerous wells have been drilled, in Manitoba. These, encountered saline waters, which have been made use of in the manufacture of salt. For convenient reference in this report, the localities where these waters have been found have been divided, tentatively, into three districts. This division is in no way based on geological or chemical considerations, and there is not the slightest reason to believe that any such division along these lines could be made

at the present time, hence the division is purely for convenience of reference, as the flowing springs, with few exceptions, occupy a distinct district, while the wells encountering saline waters have naturally grouped themselves locally.

THE WINNIPEGOSIS DISTRICT.

In this district the saline waters all appear in the form of flowing springs. The area in which these springs occur, is approximately confined to the west shore of Lake Winnipegosis, and the district between Lake Winnipegosis and Porcupine and Duck mountains on the west. The southern boundary is Dauphin lake; and the northern boundary the northern shore of Dawson bay. In this area, as outlined, numerous saline springs are known to rise to the surface through the till which covers the district in question.

The topography of the district is that of a low lying country, at an average elevation of only a few feet above the level of the water of Lake Winnipegosis. To the west the prominent ridge of the Manitoba escarpment rises to a height of from 1,000 to 1,500 feet above the surrounding country. The whole area is, with the exception of small portions of the southern part, covered with a growth of small pine, spruce and poplar, which increase in size farther to the north.

The saline springs throughout this district are very numerous, and many small saline areas can be noticed where the brine oozes up through the overlying drift.

Mr. J. B. Tyrrell, who visited a number of these springs during the summer of 1869, gives the following list of some of the principal places where saline springs have been observed¹:—

1. "Salt Creek, west of Lake Dauphin.
2. Banks of Mossy River.
3. Salt Point, south end Lake Winnipegosis.
4. Monkman's Salt Springs, Red Deer Peninsula, Saline Spring I.
5. Pine Creek. Saline Springs H and I.
6. Pelican Bay, mouth of Pelican Creek.
7. Pelican Bay, west side.

¹Geol. Survey of Canada, Vol. V, Pt. 1, p. 219E.

8. Mouth of Bell River. Saline Spring A.
9. Salt Point.
10. Salt Point Peninsula, wide salt area near its base. Saline Spring B.
11. Salt Point Peninsula, north side of its base. Saline Springs C and CC.
12. Mouth of Steep Rock River.
13. Lower Red Deer River, many places. Saline Springs E, F and G.
14. Banks of Shoal River.
15. Mouth of Swan River."

The writer visited the more important of these saline areas during the fall of 1913. The springs then visited, and referred to in this report, are indicated by distinguishing numbers opposite the corresponding localities in Mr. Tyrrell's list. Detailed reference to each of these springs is made further on, in this chapter. The descriptions of the localities not visited by the writer, are taken from previous writings.

(1). *Salt Creek, west of Lake Dauphin.*

No special description of this locality is given by Mr. Tyrrell.

(2). *Banks of Mossy River.*

No available description. This river empties into Lake Winnipegosis through low marshy meadow land. The water, oozing up in places through these marshes is distinctly saline. An attempt was made last fall (1913), to locate rock salt in places by a drill hole at Winnipegosis near the mouth of this river, but with no success at the time it was visited by the writer. One of the inhabitants of this town informed me that during the winter when the lake was frozen there was always an open patch in the ice opposite the mouth of Mossy river and about one-half mile from shore. This is supposed to be due to a saline spring rising in the bottom of the lake at this point.

(3). *Salt Point, south end Lake Winnipegosis.*

Saline springs have been noticed in a marshy district at this point.

(6). *Pelican Bay, mouth of Pelican Creek.*

At this locality, Mr. Tyrrell noted and obtained a sample from springs issuing from the summit of a bare hill, rising 30 feet above the surrounding country. This hill, situated a third of a mile back from the shore of Pelican bay, just east of the mouth of Pelican creek, extends as a ridge in a direction N. 75° E. The sample taken analyzed as follows¹:—

In 1000 nts. by weight.		<i>Hypothetical Combination.</i>	
Potassium.....	1.296	Chloride of Potassium..	2.473
Sodium.....	20.054	Chloride of Sodium....	51.005
Calcium.....	1.247	Chloride of Magnesium	1.120
Magnesium.....	0.313	Sulphate of Lime.....	4.240
Sulphuric Acid (SO ₄)....	3.114	Sulphate of Magnesia..	0.151
Chlorine.....	32.888		

Specific Gravity, at 15.5° C., 1.039.

Total dissolved matter, by direct experiment, dried at 180° C. = 59.080.

It contained a trace of lithium, faint traces of bromine, and a trace of iodine. Barium and strontium were absent.

These springs are situated, N. lat. 52° 38' 30"; W. long. 100° 21'. The flow from them was 25 gallons per minute when the sample was taken on the 21st of July, 1889.¹

(7). *Pelican Bay, west side.*

At this locality Mr. Tyrrell describes the spring as follows²:—

"A quarter of a mile back from the shore, among woods of small spruce, is a considerable tract of arid land covered with a crust of salt, from which the almost dry channel of a small saline brook descends to the lake."

¹F. G. Wait., Analyst.

²See Tyrrell on Northern Manitoba, Geol. Surv. Can., Vol. V, Pt. 1E; also Hoffman & Wait, Vol. V, Pt. 2, p. 28R.

³Geol. Surv. Can., Vol. V, Pt. 1, p. 63E.

(9). *Salt Point.*

In the vicinity of Salt Point several saline springs occur. When mentioning this as a special locality, he probably was referring to a saline creek which he found flowing into Dawson bay, and which he described as follows:¹

Two miles and three-quarters north of the mouth of Bell river is a bare flat, over which a small brook flows into the lake, behind which are some ridges of impure sand. The creek, when examined on the 1st of August, 1889, was flowing sixty gallons a minute and the water was very saline, containing about six-sevenths of a pound of common salt to the gallon, which would give a total discharge by the brook of about thirty-seven tons of salt every twenty-four hours. The summer of 1889 was a particularly dry one and during ordinary seasons, with an average amount of rainfall, the brine would doubtless be somewhat weaker, but on the other hand the quantity of brine discharged and probably of salt also would be greater. This brook flows from several springs a mile or more farther inland, which are described elsewhere.

The analysis of the brine collected by Mr. Tyrrell from this brook is as follows²:—

It contained in 1,000 parts by weight:—

<i>Hypothetical combination.</i>			
Potassium.....	0.067	Chloride of Potassium...	1.158
Sodium.....	32.415	Chloride of Sodium.....	82.970
Calcium.....	1.681	Chloride of Magnesium...	1.686
Magnesium.....	0.478	Sulphate of Lime.....	5.715
Sulphuric Acid (SO ₄)....	4.243	Sulphate of Magnesia...	0.261
Chlorine.....	50.118		

F. G. Wait, analyst

Specific gravity, at 15.5° C., 1.063.

Total dissolved solid matter, by direct experiment, dried at 180° C., 88.946.

It contained traces of lithium, but neither barium nor strontium. Bromine and iodine were not sought for.

Location: N. lat. 52° 47' 40"; W. long. 100° 51'.

The writer, last summer, made search for this brook, but was unable to locate it anywhere near the locality above given. In the neighbourhood of saline spring B (see sketch map Fig.

¹Geol. Surv. Can. Vol. V, Pt. 1, pp. 178 and 179, E.

²Geol. Surv. Can., Vol. V, pt. 2, p. 29K.

No. 8), there were evidences that a stream of considerable size had at one time flowed over the flat; but the flow at the present time is practically at a standstill. This might possibly be the brook to which Mr. Tyrrell referred.

(12.) *Mouth of Steep Rock River.*

This area was not visited, as the Indians living a few miles distant from it stated that the springs were dried up at the present time.

Situated three-quarters of a mile north of Steep Rock river, Mr. Tyrrell found this spring, when he visited it on August 6, 1889, to be flowing 4 gallons per minute.

Location: N. lat. $52^{\circ} 48' 30''$; W. long. $100^{\circ} 57'$.

He describes this locality as follows¹:—

Also three-quarters of a mile north of the mouth of Steep Rock river a hill fifty-five feet in height forms a salient point projecting into the lake. . . . At the edge of the water is an irregular bedded, rather coarse-grained, saccharine limestone, dipping at about 5° from N.E. to E. In places it is pure white and in other places it is of a dark brownish colour, and through it rise a number of springs of brine.

The sample taken analyzed as follows²:—

It contained in 1,000 parts by weight:—

Hypothetical combination.

Potassium.....	1.509	Chloride of Potassium..	2.879
Sodium.....	18.393	Chloride of Sodium.....	46.781
Calcium.....	1.198	Chloride of Magnesium..	1.399
Magnesium.....	0.357	Sulphate of Lime.....	4.073
Sulphuric Acid (SO ₄)....	2.889	Sulphate of Magnesia..	0.017
Chlorine.....	30.647		

F. G. Wait, analyst.

Specific gravity, at 15.5° C., 1.039.

Total dissolved solid matter, by direct experiment, dried at 180° C., 54.579.

It contained a trace of lithium. Barium, strontium. Bromine and iodine were not sought for.

¹Geol. Surv. Can. Vol. V, Pt. 1, p. 182E.

²Geol. Survey of Can., Vol. V, Pt. 2, p. 27R.

(14). *Banks of Shoal River.*

Mr. Tyrrell noticed on ascending Shoal river to the north end of Swan lake, that along the banks of the stream occasional areas are rendered wet and barren by flows of brine from salt springs.

(15). *Mouth of Swan River.*

At the south end of Swan lake a small brine spring is flowing out on the shallow, muddy beach, while a short distance back in the woods a hill rises to a height of between 200 and 300 feet.¹

A sample taken by Mr. Tyrrell on August 31, 1889, analyzed as follows²:—

It contained in 1000 parts by weight:—

Hypothetical combination.

Potassium.....	1.004	Chloride of Potassium..	1.916
Sodium.....	17.546	Chloride of Sodium.....	44.626
Calcium.....	1.196	Chloride of Calcium....	0.144
Magnesium....	0.272	Chloride of Magnesium.	1.077
Sulphuric Acid (SO ₄)...	2.747	Sulphate of Lime.....	3.891
Chlorine.....	28.904		

F. G. Wait, analyst.

Specific Gravity, at 15.5° C., 1.035.

Total dissolved solid matter, by direct experiment, dried at 180° C., 51.559.

It contained a trace of lithium, but no barium or strontium.¹ Bromine and iodine were not sought for.

This spring is located half a mile back from the west shore of Swan lake, between it and the lower portion of Swan river. N. lat. 52° 26' 35"; W. long. 100° 42' 45". At the time of sampling it had a flow of five gallons per minute.

The saline spring areas in the Winnipegosis district visited by the writer were very similar in appearance, and one general

¹Geol. Surv. of Can., Vol. IV, p. 23A.

²Geol. Surv. Can.

description for them all will suffice. In general, they consist of a barren area, varying from a few acres to over a hundred acres in extent, devoid of any vegetation, with the occasional exception of scattered patches of the red salt plant (*Salicornia herbacea*). Surrounding these areas there are generally a few acres of meadow land, with timber consisting of pine, spruce, and poplar, enclosing the whole area.

Here and there in the barren flat, saline springs bubble through the till, forming in some cases small truncated, conical mounds of reddish sinter, in the centre of which lie clear pools of brine. (See typical saline spring Plate XIII A.) In some of these springs bubbles of gas are constantly rising. The brine, flowing from the pools, spreads over the whole flats, and either evaporates—leaving a thin deposit of salts or, if the flow is strong enough, forms a small stream of brine.

Occasionally, the brine is found in lakes or pools some 20 or 30 feet in diameter, in which the surface is constantly moving, owing to the bubbling up of the brine from below. These are surrounded by mud flats covered by a sod of coarse bunch grass. The ground in the vicinity of this type of spring is generally marshy.

Saline Spring A.

Approximate location. Section 33, Township 24, Range 43, west of the Principal Meridian.

Temperature. Atmosphere 65° F. Brine A_1 52° . A_2 54° .

Specific Gravity (taken in field) = A_1 1.035; A_2 1.030.

Degrees of salinity (by salinometer in field) = A_1 26° ; A_2 25° .

Flow per minute.— $17\frac{1}{4}$ gallons (imperial).

Approximate areas.—Salt flat 30 acres—meadow land 7 acres.

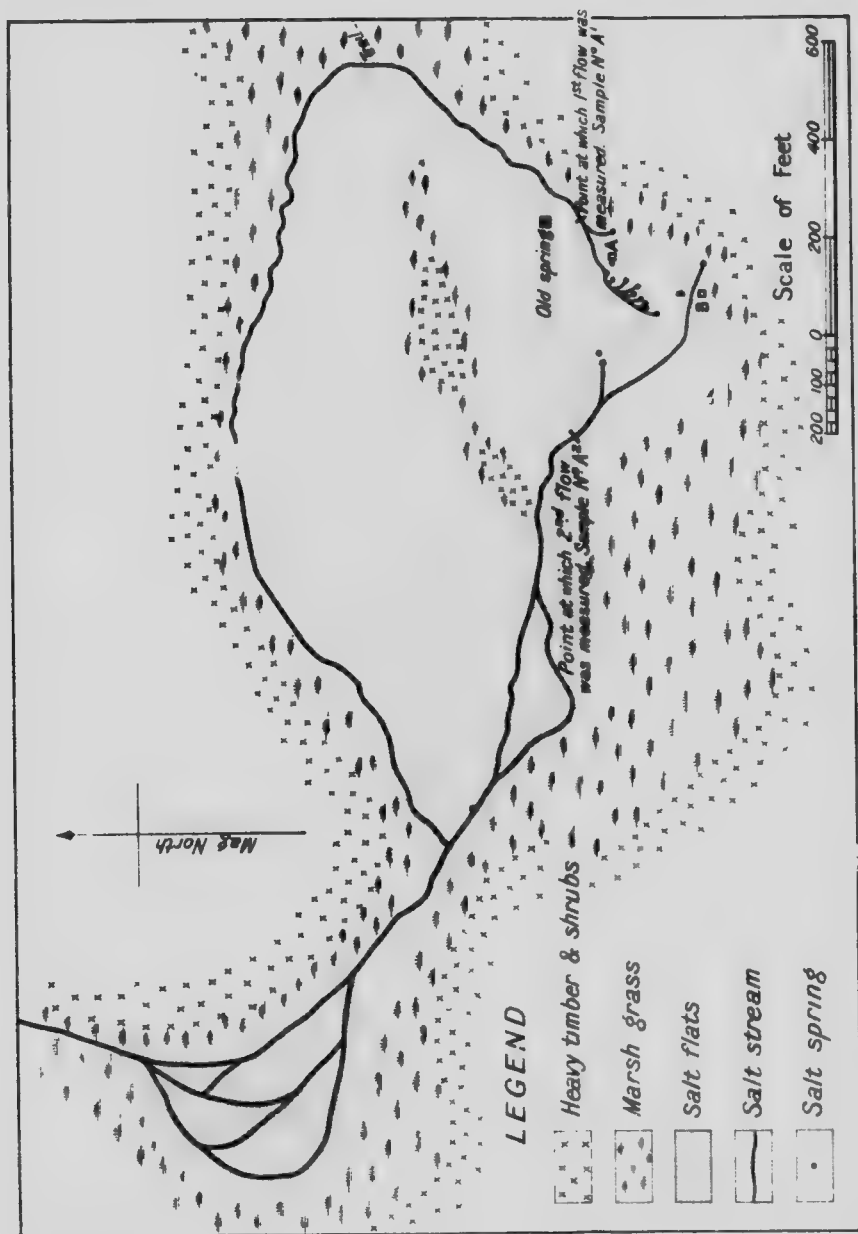


Fig 7, Saline Spring A. 1/4 mile northwest of mouth of Bell river, Dawson bay, Manitoba.



<i>Analyses.</i>		<i>Conventional Combination.¹</i>			
<i>Grammes per litre</i>					
	A ₁	A ₂		A ₁	A ₂
K.....	0.095	0.136	KCl.....	0.181	0.259
Na.....	20.710	18.529	NaCl.....	52.675	47.127
Ca.....	1.325	1.159	CaCl ₂	0.110	0.039
Mg.....	0.316	0.301	MgCl ₂	1.188	1.160
Fe & Al.....	0.006	0.005	MgBr ₂	0.124	0.064
SO ₄	3.085	2.749	CaSO ₄	4.370	3.894
Si.....	0.004	0.004	Fe & Al.....	0.006	0.005
Cl.....	34.240	30.460	Si.....	0.004	0.004
Br.....	0.108	0.056			
I.....	Nil	Nil			

Dr. J. T. Donald (Montreal), analyst².

This saline area is reached by a trail of about one-half to three-fourths of a mile in length, running in a northwesterly direction from the mouth of Bell river, at the southwest end of Dawson bay. The trail commences in a sloping meadow reaching down to the water's edge.

No visible spring is to be seen in this meadow, but it is springy and marshy, and the moisture obtainable is decidedly saline to the taste. The size of this meadow is 110 feet wide by 185 feet long, and is bordered on three sides by timber. It slopes to the S.E., with a very gradual slope of from 5° to 10° towards the mouth of the Bell river. Continuing in a westerly direction, the trail leads over a ridge of fossiliferous limestone with a rise of from 25 to 30 feet. This ridge has a bearing of north-east and southwest.

¹The following method was employed in calculating the conventional combinations from the analyses: The Potassium is united to chloride ions; the sulphate ions are joined to calcium, sodium, and magnesium in the order named; the bromide and iodide ions are united to magnesium and sodium; and the residual basic ions are united to chloride ions. In order to make the calculations balance, one has to either add or subtract a certain amount of chlorine—which is either lacking or in excess in the analyses—in order to satisfy the braces. It may be that what appears to be a deficiency in chlorine is in reality the equivalent of the carbonic acid radical, which was not determined in the analysis. Some of the brines submitted to Dr. Donald were distinctly alkaline in reaction.

²Dr. Donald states in his returns:—"In addition to the determinations for which figures are given, search has been made for lithium, barium and strontium. We have not been able to detect the presence of any of these elements. It is to be noted, however, that when search is made for these, it is usual to work up a much larger volume of solution than was at our disposal. It may be that one or more of the three would be found in some of the samples if a larger quantity of material were available."

The trail descends again into lower and marshy ground and continues in a northwesterly direction for perhaps a little over one-fourth of a mile through a heavy spruce forest. Coming out of the timber one comes into the meadow land which borders the salt flats. (See sketch map Fig. 7.)

The general description of a salt spring area already given is sufficient to describe this area.

When visited on September 13, 1913, there were about 15 springs bubbling up through the till. The overflow from these forms two small streams which unite at the end of the meadow land and flow into Dawson bay.

Two samples were taken from this area, at the points marked on the sketch map. Analyses of these samples are given above. Plate XI gives a general view of this area.

Saline Spring B.

Approximate location.—Section 23, Township 24, Range 24, west of the Principal Meridian.

Temperature.—68° F. Brine B₁ 62° F.; B₂ 44° F.

Specific Gravity.—(taken in field) B₁ 1.040; B₂ 1.040.

Degrees of salinity (by salinometer in field):—B₁ 26°; B₂ 25°.

Flow per minute.—7½ gallons (imperial).

Approximate areas.—Salt flat 140 acres—meadow land 25 acres.

Analyses.

			<i>Conventional combinations</i>		
			<i>Grammes per litre.</i>		
	<i>B₁*</i>	<i>B₂* Tyrrell's†</i>	<i>B₁*</i>	<i>B₂* Tyrrell's†</i>	
K	0.352	0.231	1.044 KCl	0.672	0.441 1.992
Na	22.191	21.629	19.819 NaCl	56.440	54.020 50.408
Ca	1.424	1.443	1.251 CaCl ₂	0.224	0.258 0.108
Mg	0.351	0.345	0.328 MgCl ₂	1.226	1.318 1.299
Fe&Al . .	Traces	0.003	 MgBr ₂	0.123	0.092
SO ₄	3.299	3.243	2.909 CaSO ₄	4.572	4.593 4.121
Si	0.002	0.009	 Fe&Al	Traces	0.003
Cl	35.620	35.280	32.357 Si	0.002	0.009
Br	0.107	0.080	Nil		
I	Nil	Nil	.....		

*Dr. J. T. Donald, analyst.

†F. G. Wait, analyst. (See Geol. Surv. Can., Vol. V, Pt. 2, p. 28-29E.)

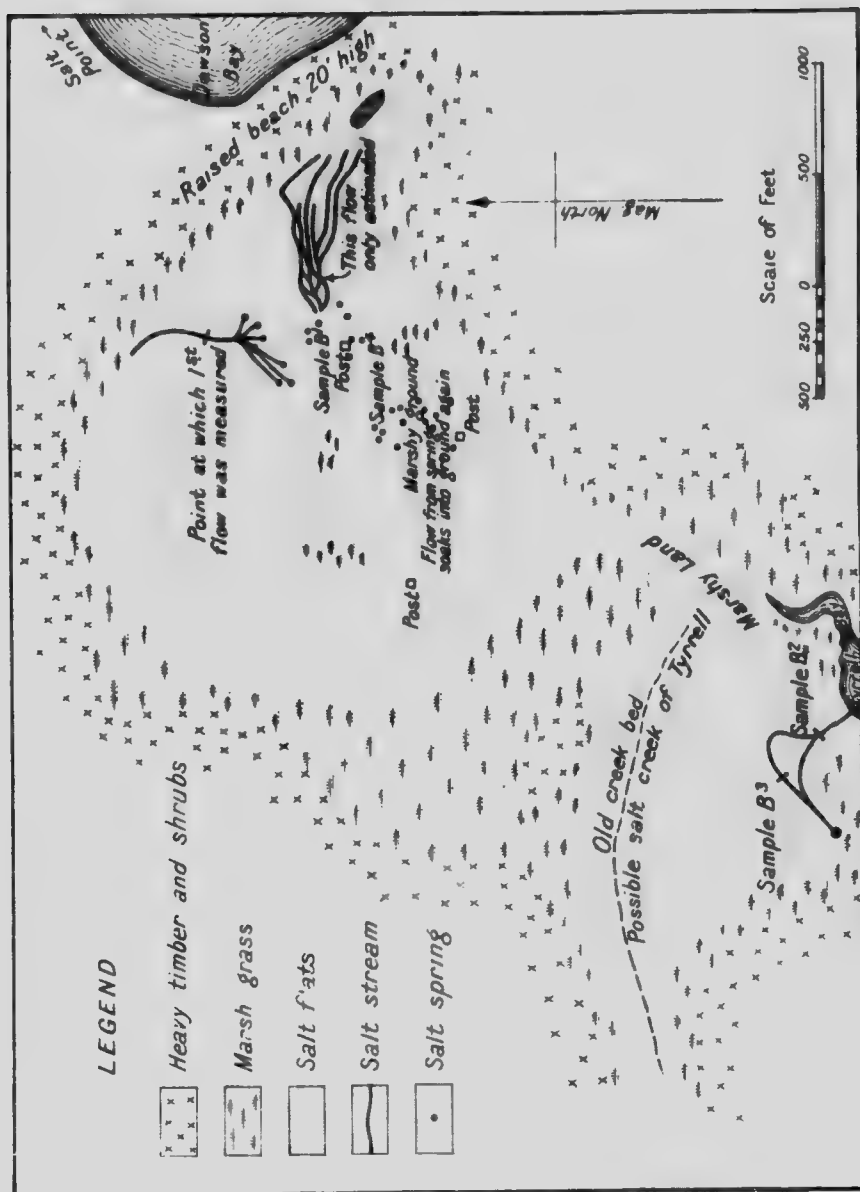


Fig. 8, Saline Spring B. South side of Salt point, Dawson bay, Manitoba.





Salt flats, Saline Spring A, Winnipegosis dist



A, Winnipegosis district, Manitoba.









Salt flats, Saline Spring B, Winnipegosis district, Manitoba.



Winnipegosis district, Manitoba.

PLATE XII.



PLATE XIII.



A. Typical saline spring, Saline Spring E, Winnipegosis district, Manitoba.



B. Typical saline pond, Saline Spring B, Winnipegosis district, Manitoba.

Samples B₁ and B₂ were taken from different points, as shown on sketch map, Fig. 8. The flow was measured in two places. The brine from the large pool (See Plate No. XIII B), where sample No. B₁ was taken could only be estimated, as it almost immediately sank into the ground which was very porous.

A few inches under the surface in these flats the till was jet black, and in order to ascertain its composition a sample of the material was taken and analyzed as sample No. B₄. The material, also found in the bottom of the spring, was gathered as sample No. B₃ and analyzed with the following results:--

	B ₃	B ₄
Volatile***	6.75	1.90
NaCl.....	3.35	3.26
SiO ₂	0.41	18.10
CO ₂ *	35.60	31.80
SO ₃ **	2.86	0.52
Fe ₂ O ₃	5.43	1.63
Al ₂ O ₃	0.07	1.87
CaO.....	44.88	38.61
MgO.....	0.82	2.56
*Equivalent CaCO ₃	80.90	72.27
**Equivalent CaSO ₄	4.86	0.88
Equivalent CaSO ₄ ·2H ₂ O.....	6.14	1.12
***Loss on ignition other than CO ₂ .		

Dr. J. T. Donald, analyst.

It will be seen from these analyses that the material composing the salt flats is mostly lime carbonate, derived probably from the limestones through which the springs rise. The analysis of brine probably from this spring taken by Mr. Tyrrell on August 2, 1889, is given for comparison. He then found the flow to be 20 gallons per minute. Plate XII gives a good idea of the character of this spring area.

Saline Spring C.

Approximate location.—Section 17—Township 24—Range 44 west of the Principal Meridian.

Temperature.—Atmosphere 60° F. Brine 44° F.

Specific Gravity (taken in field):—1.040.

Degrees of salinity (by salinometer in field):—26°.

Flow per minute.—45½ gallons (imperial).

Approximate areas.—Salt flats 16 acres—meadow land 2 acres.

Analyses.

Conventional Combinations

Grammes per litre.

	C*	Tyrrell's†		C*	Tyrrell's†
K	0.113	1.296	KCl	0.216	2.473
Na	20.406	20.054	NaCl	51.675	51.005
Ca	1.200	1.231	CaCl ₂		
Mg	0.304	0.315	MgCl ₂	1.180	1.176
Fe & Al	0.110		MgBr ₂	0.047	
SO ₄	2.993	3.025	Na ₂ SO ₄	0.167	
Si	0.004		CaSO ₄	4.080	4.185
Cl	34.240	32.732	Fe & Al	0.110	
Br	0.041		Si	0.004	
I	Nil		MgSO ₄		0.089

This spring (See Fig. 9) consists of one main spring rising through a cone formed by itself at the top of the hill. It has a diameter of about 2 feet, and at the time of visiting had a strong and constant flow. Bubbles of gas were constantly rising to the surface. This was found to be non-inflammable and a sample was taken, and analyzed as sample C₂, as follows:—

Carbon dioxide	0.8 per cent.
Oxygen	17.7
Ethylene	
Carbon monoxide	
Methane	
Hydrogen	
Nitrogen	81.5 per cent.
	(by difference).

Analyst, Dr. F. E. Carter, Fuel Testing Division, Mines Branch, Ottawa.

*Dr. J. T. Donald, analyst.

†F. G. Wait, analyst. (See Geol. Surv. of Canada, Vol. V, Pt. 2, p. 28-29E.)

A number of semicircular mounds appear on the natural slope of the hill at this point. These have probably been built up by springs issuing at different points. A sample of the material from one of these mounds was taken and analyzed as follows:—

	C ₃ .
Volatile***	5.90
NaCl	0.66
SiO ₂	2.61
CO ₂ *	32.40
SO ₃ **	1.51
Fe ₂ O ₃	14.46
Al ₂ O ₃	Traces.
CaO	42.07
MgO	0.57
*Equivalent:—CaCO ₃	71.36
**Equivalent CaSO ₄	2.57
Equivalent CaSO ₄ . 2H ₂ O	3.25
***Loss on ignition other than CO ₂	

Dr. J. T. Donald, analyst.

About 10 years ago an attempt was made to manufacture salt from the brine of this spring, but operations were soon abandoned. The small salt block which was then employed can still be seen in the log cabin shown in the sketch map. Two pans were used, side by side, with a fire box at one end. The pans measured 6 ft. × 3 ft. × 6 inches deep. A good view of this spring is given in the Frontispiece.

Saline Spring CC.

This is presumably part of Spring C and is situated about 300 yards to the east. There was no definite spring at this place, but the ground at the top of the slope was soggy and half-way down the slope the water from this marshy area was sufficient to form a small stream which flowed $1\frac{1}{4}$ gallons per minute. The salinity, as measured, was 26° on the salinometer. See sketch map, Fig. 9.

Saline Spring D.

Approximate location.—Section 11—Township 25—Range 44 west of Principal Meridian.

Temperature.—Atmosphere 61° F. Brine 60° F. (exposed to surface)¹.

Specific Gravity.—(taken in field).—1.025.

Degrees of salinity (by salinometer in field).—12°.

Flow per minute.—15½ gallons (imperial).²

Approximate areas.—Salt flat 2 acres—meadow lands 115 acres.

*Analysis.**Conventional Combination.*

K.....	0.009	KCl.....	0.017
Na.....	10.223	NaCl.....	25.750
Ca.....	0.600	CaCl ₂	
Mg.....	0.195	MgCl ₂	0.772
Fe & Al.....	0.009	MgBr ₂	Traces
SO ₄	1.646	Na ₂ SO ₄	0.305
Si.....		CaSO ₄	2.040
Cl.....	16.340	Fe & Al	0.009
Br.....	Traces	Si.....	
I.....	Nil		

Analyst, Dr. J. T. Donald.

This spring is one of the second type, as previously described. It consists of a shallow pond of brine surrounded by a number of small springs, from which a stream flows through meadow land, finally emptying into Steeprock river. The whole area is marshy and spongy under foot, and the barren part is small. The brine is weaker than many of the others examined, but the flow is strong. The whole area is surrounded by timber, and the spring is reached by ascending the Steeprock river for about a mile from its mouth. See Fig. 10.

¹On account of the brine being in a large shallow pond the temperature is accordingly high. A small bubbling spring directly to the south of this pool gave a temperature of 40° F.

²Only one measurement of the flow was taken. Probably 30% more can be added to the figure thus obtained, as a large quantity was absorbed by the flats before the point was reached at which this flow was taken. This would make a flow of approximately 20 gallons per minute.

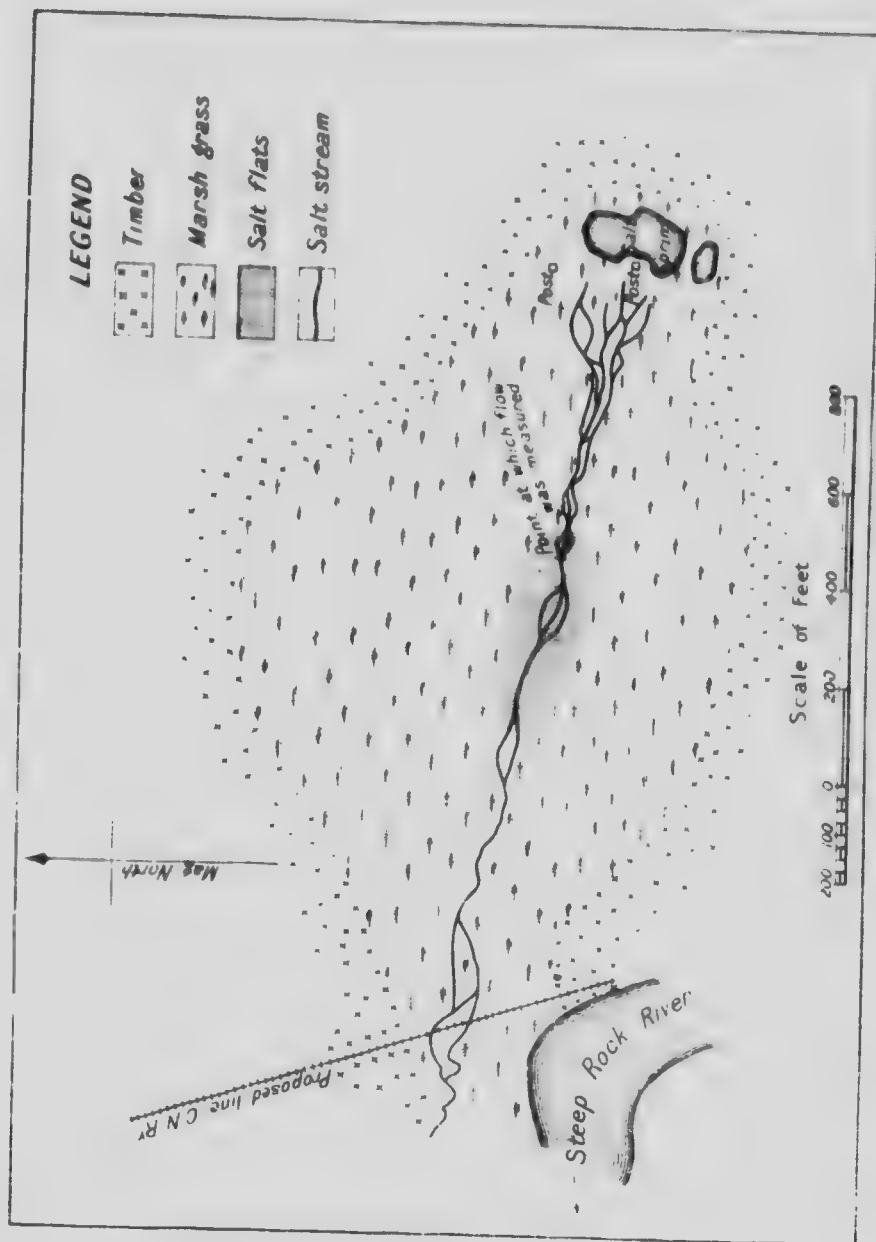


Fig. 10, Saline Spring D. Steep Rock river, Manitoba.

Saline Spring E.

Approximate location.—Section 16—Township 25—Range 45 west of the Principal Meridian.

Flow per minute.—1 gallon (imperial) estimated.

Approximate areas.—Salt flats 10 acres—meadow land 60 acres.

The spring is situated on the west bank of the Red Deer river, about $1\frac{1}{4}$ miles from its mouth. The flow from this spring was only estimated, for when it was visited on September 17, 1913, there was only a small seepage from the marshy part of the area. There is probably a stronger flow during the wet season of the year. See Fig. No. 11.

Mr. Tyrrell visited this spring on August 13, 1889, and obtained a sample, which analysed as follows:—

<i>Analysis.</i>	<i>Hypothetical Combination.</i>
Potassium..... 0.832	Chloride of potassium.. 1.587
Sodium..... 15.124	Chloride of sodium..... 38.466
Calcium..... 1.094	Chloride of calcium..... 0.394
Magnesium..... 0.354	Chloride of magnesium. 1.401
Sulphuric acid (SO ₄).... 2.285	Sulphate of lime..... 3.327
Chlorine..... 25.494	

Total dissolved solid matter, by direct experiment, dried at 180° C.—45.027.

It contained a trace of lithium, and faint traces of iodine, but no bromine. Barium and strontium were also absent.

He found a flow of 2 gallons per minute. Location.—N. lat. 52° 53' 20"; W. long. 101° 2' 15".

Saline Spring F.

Approximate location.—Section 18—Township 25—Range 45 west of Principal Meridian.

Temperature.—Atmosphere 57° F. Brine 52° F.

Specific Gravity (taken in field).—1.030.

Analyst, F. G. Wait. (See *Geol. Sur. Can. Vol. V. Pt. 2, p. 33R.*)

Degrees of salinity (by salinometer in field) 21°.

Flow per minute.—3½ gallons (imperial).

Approximate areas.—meadow land 20 acres.

Analysis.

Conventional Combination.

Grammes per Litre.

K.....	0.011	KCl.....	0.021
Na.....	18.716	NaCl.....	47.604
Ca.....	1.134	CaCl ₂	0.142
Mg.....	0.343	MgCl ₂	1.350
Fe & Al.....	0.004	MgBr ₂	0.017
SO ₄	2.600	CaSO ₄	3.683
Si.....		Fe & Al.....	0.004
Cl.....	29.080	Si.....	
Br.....	0.015		
I.....	Nil		

Analyst, Dr. J. T. McDonald.

This spring is situated on the west bank of the Red Deer river, about 2½ miles from its mouth. It apparently has its rise from the base of a limestone ridge, about 25 feet in height, above the river. The flow from this spring runs in two small streams into the river. The springs themselves lie in a marshy piece of meadow directly at the foot of the ridge above referred to. See Fig. No. 12. Plate XIV, A and B, shows two views taken at this spring.

Saline Spring G.

Approximate location.—Section 11—Township 26—Range 45 west of the Principal Meridian.

Temperature.—Atmosphere 76° F. Brine 42° F.

Specific Gravity (taken in field)—1.035.

Degrees of salinity (by salinometer in field).—24°.

Flow per minute.—7½ gallons (imperial).

Approximate areas.—Salt flats 105 acres—meadow land 10 acres.

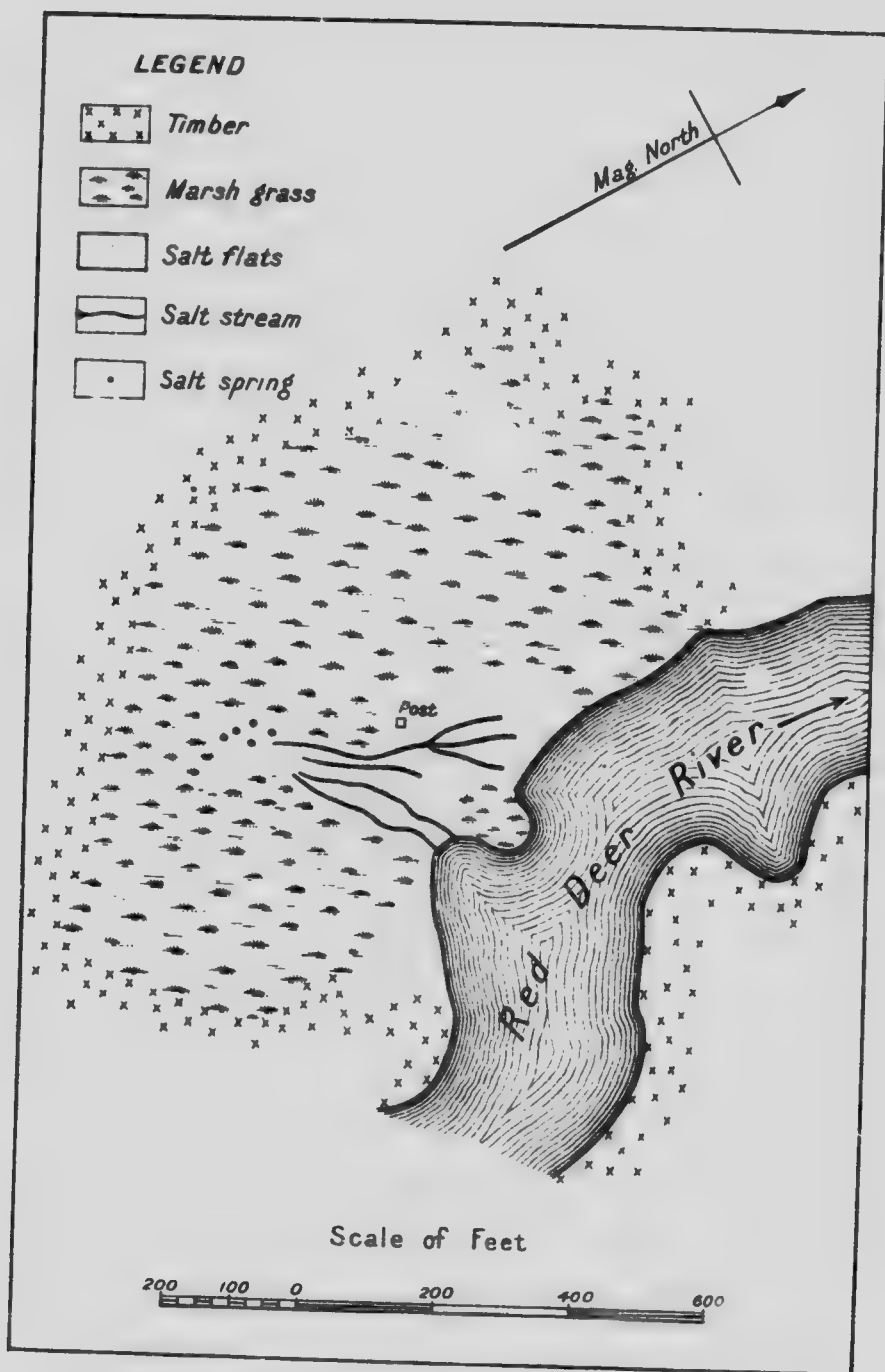


Fig. 11, Saline Spring E. West bank Red Deer river, $1\frac{1}{2}$ miles from mouth.

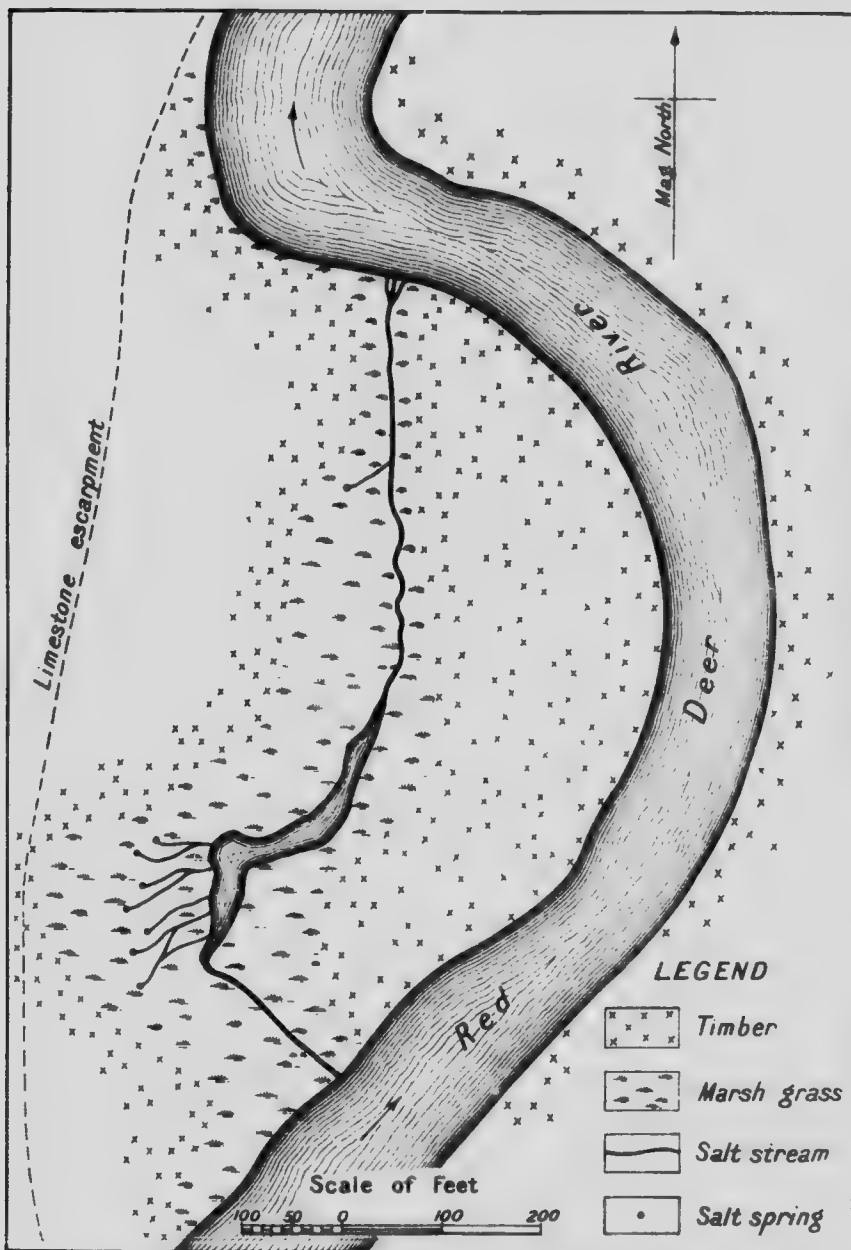


Fig. 12, Saline Spring F. West bank Red Deer river, about $2\frac{1}{2}$ miles from mouth.

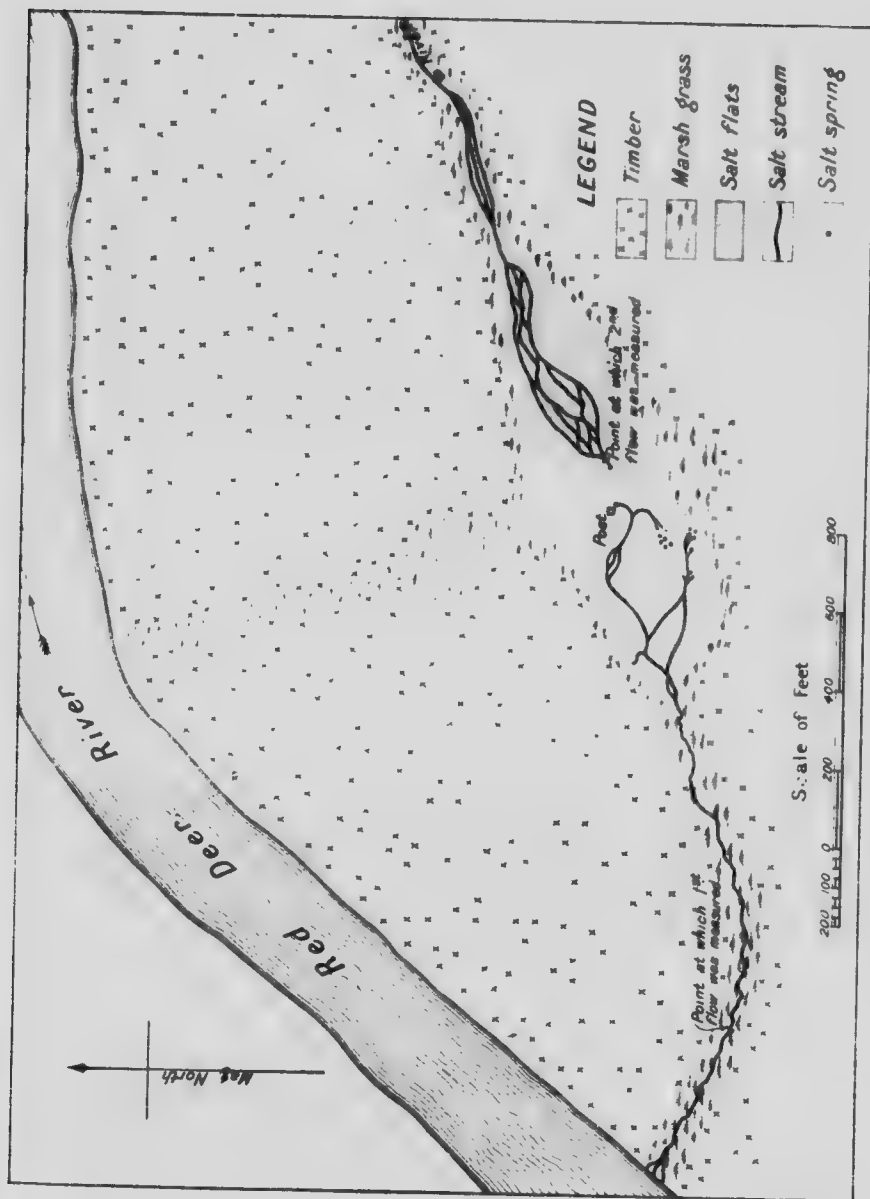


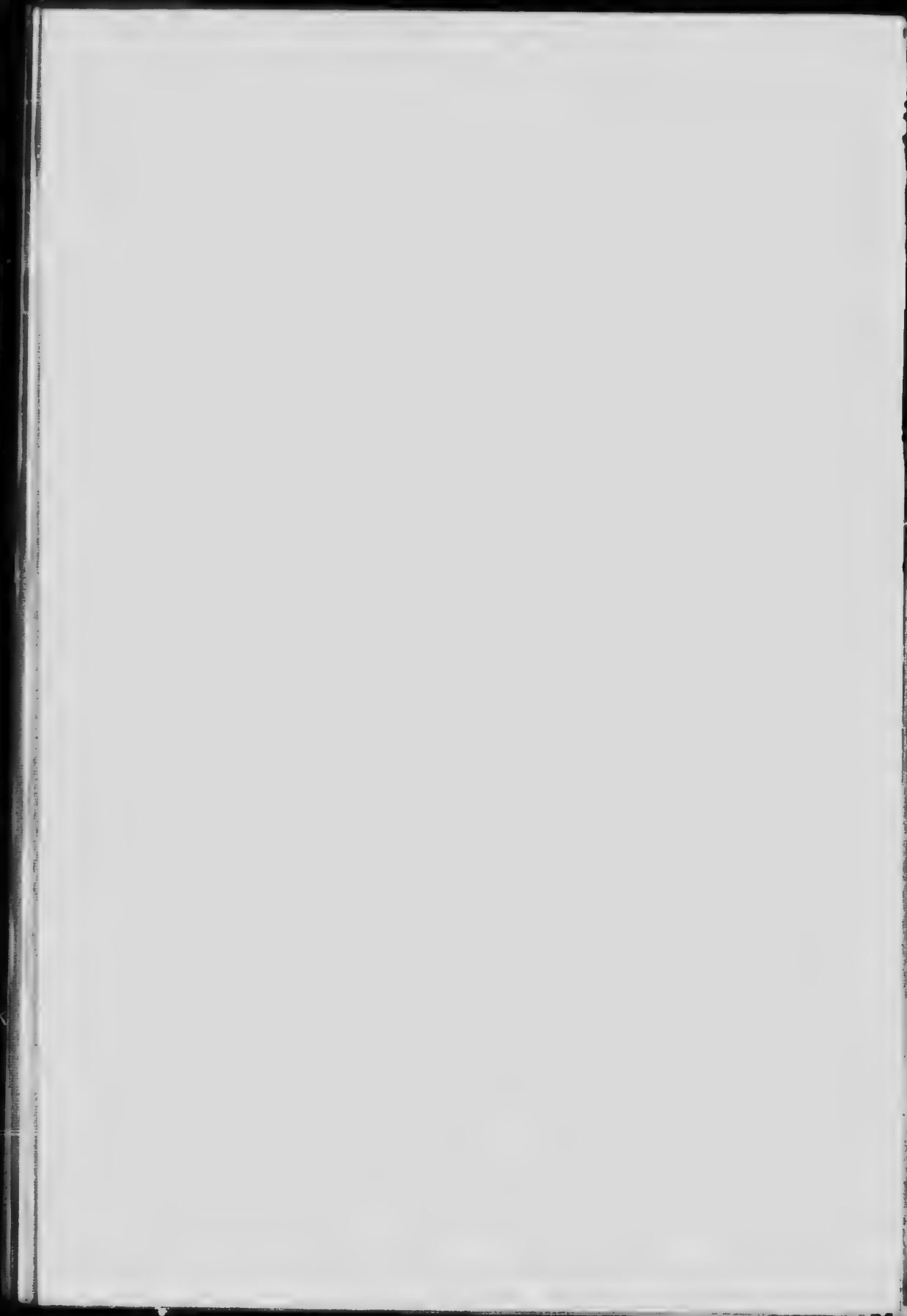
Fig 13, Saline Spring G. South shore Red Deer river, about 4 miles from mouth.

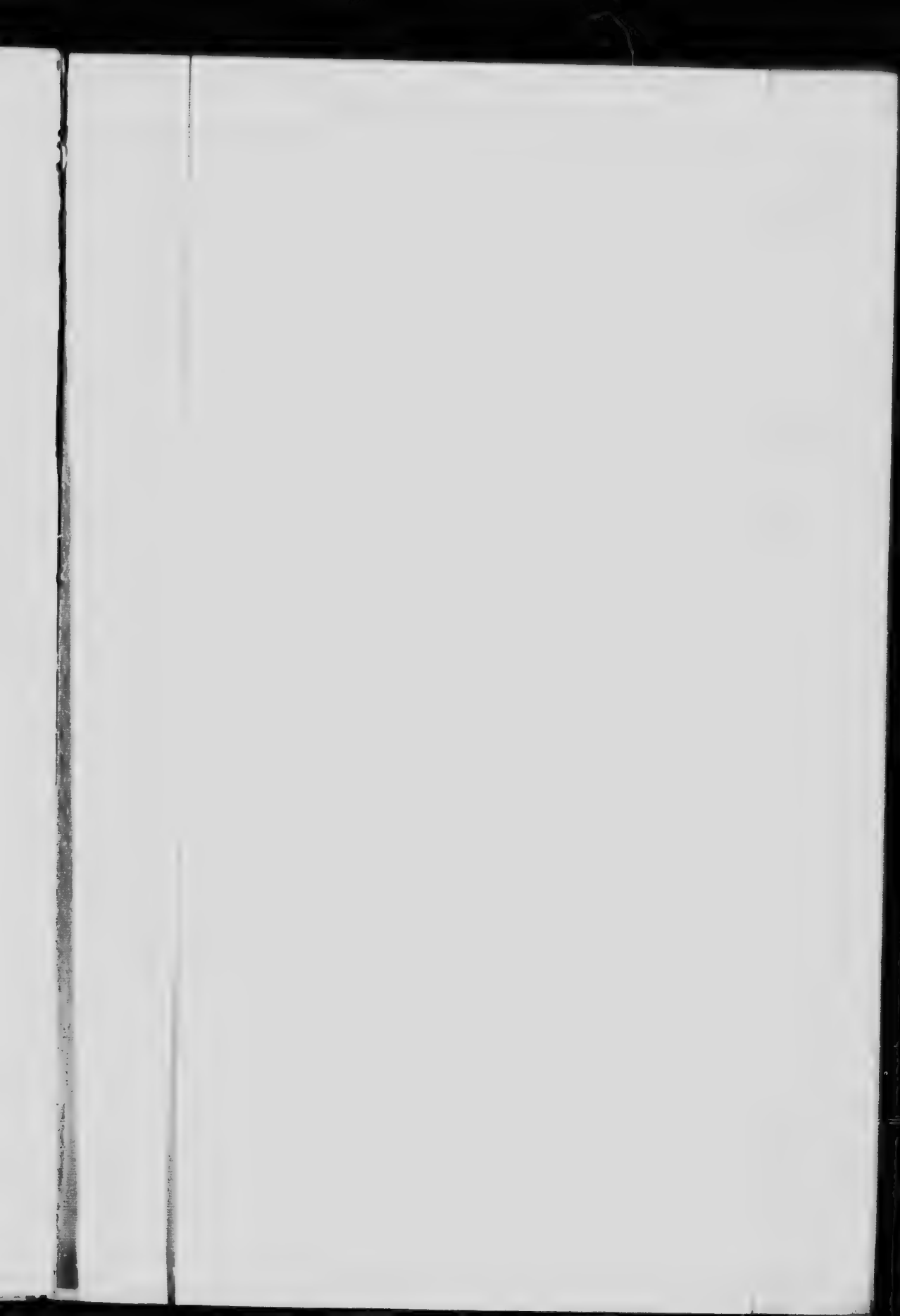


A. Saline stream from Saline Spring F, Red Deer river, Winnipegosis district, Manitoba.



B. Saline Spring F, Red Deer river, Winnipegosis district, Manitoba.







Saline Spring G, Red Deer river, W

PLATE XV



er river, Winnipegosis district, Manitoba.

*Analyses.**Conventional Combinations.**Grammes per litre.*

	<i>G</i> ¹	<i>Tyrrell's</i> ²		<i>G</i> ¹	<i>Tyrrell's</i> ²
K.....	0.006	1.181	KCl.....	0.011	2.253
Na.....	19.413	18.524	NaCl.....	49.377	47.114
Ca.....	1.185	1.156	CaCl ₂	0.191	.....
Mg.....	0.329	0.277	MgCl ₂	1.261	1.061
Fe & Al.....	0.005	.....	MgBr ₂	0.025	.....
SO ₄	2.678	2.812	CaSO ₄	3.794	3.930
Si.....	.....	.....	Fe & Al.....	0.005	.....
Cl.....	29.600	29.805	Si.....	.....	.....
Br.....	0.022	.....	MgSO ₄.....	.....	0.047
I.....	Nil	.....			

This spring is situated on the south bank of the Red Deer river, 4 miles from its mouth. Mr. Tyrrell examined it on September 9, 1889, and found it flowing 10 gallons per minute. See Fig. No. 13. Plate XV gives a general view of this area.

Saline Spring H.

Approximate location.—Section 2—Township 20—Range 35 west of the Principal Meridian.

Temperature.—Atmosphere 54° F. (6 P.M.). Brine 42° F.

Specific Gravity (taken in field).—1.025.

Degrees of salinity (by salinometer in field).—15°.

Flow per minute.—14½ gallons (imperial).

Approximate areas.—Salt flats 12 acres, situated in prairie.

¹Dr. J. T. Donald, analyst.

²F. G. Wait, analyst. (See Geol. Surv. Can., Vol. V, Pt. 2, p. 34R.)

*Analysis.**Conventional Combination.**Grammes per litre.*

K.....	0.071	KCl.....	0.135
Na.....	12.107	NaCl.....	30.707
Ca.....	0.855	CaCl ₂	
Mg.....	0.212	MgCl ₂	0.827
Fe & Al.....	0.006	MgBr ₂	0.021
SO ₄	2.123	CaSO ₄	2.907
Cl.....	18.240	Na ₂ SO ₄	0.105
Br.....	0.018	Fe & Al.....	0.006
I.....	Nil		

Analyst, Dr. J. T. Donald.

This spring is situated about 4 miles southwest of Camperville, on Pine creek, in meadow land which extends for several miles, with occasional clumps of bushes and trees, called locally bluffs. Gas is constantly bubbling up in the spring, which is about 10 to 12 feet in diameter. A strong stream is formed from the overflow, which, however, is soon seeped up by the dry till. See Fig. No. 14.

Saline Spring I.

Approximate location.—Section 1—Township 20—Range 35 west of the Principal Meridian.

Temperature.—Atmosphere 51° F. (7 P.M.). Brine 42° F.

Specific gravity (taken in field).—1.015.

Degrees of salinity (by salinometer in field).—10°.

Flow per minute.—14½ gallons (imperial).

Approximate areas.—Salt flats 1 acre.

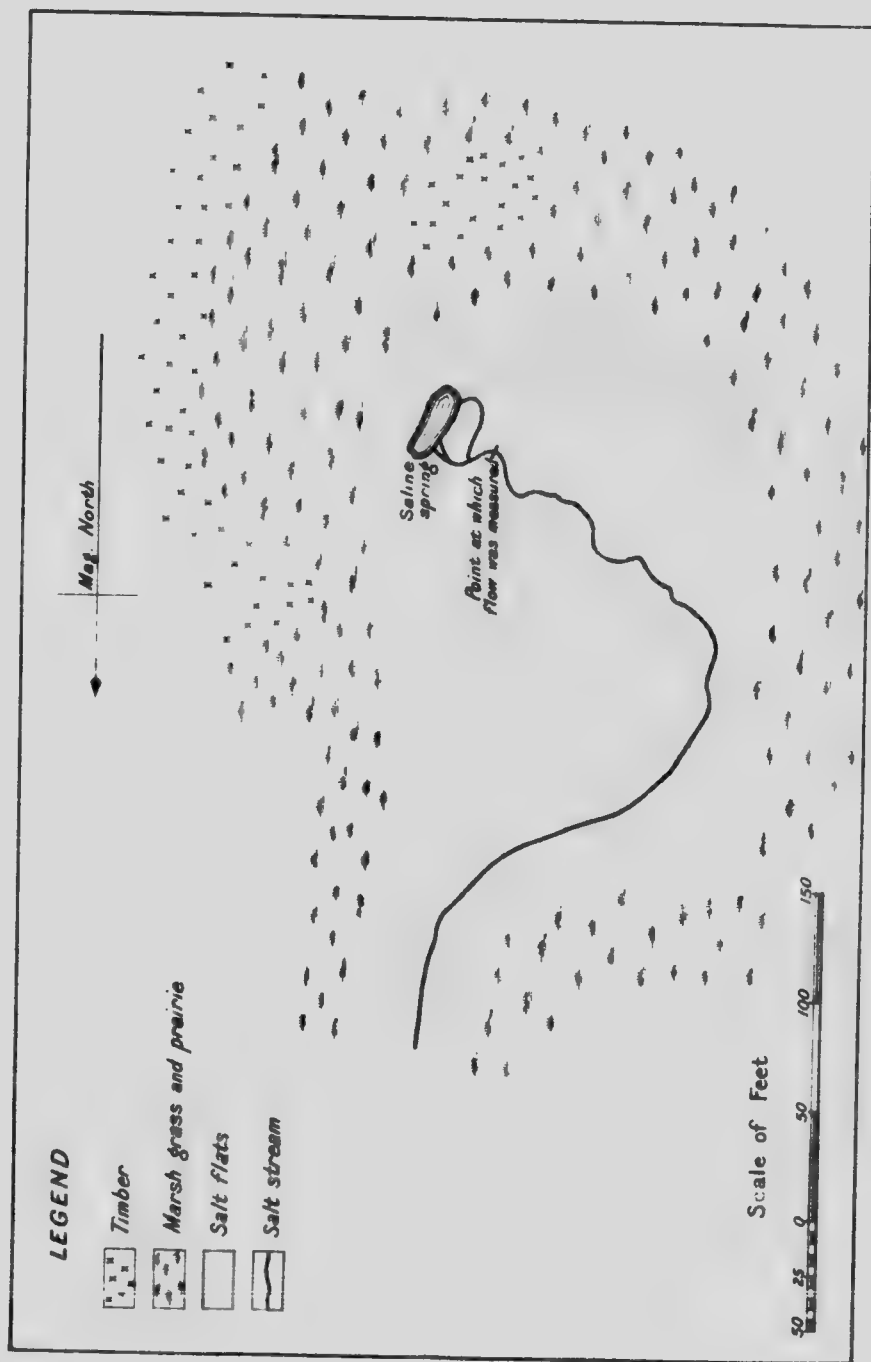


Fig. 14, Saline Spring H. About 4 miles s.w. of Camperville, Lake Winnipegosis, Manitoba.



*Analysis.**Conventional Combination.**Grammes per litre.*

K.....	0.003	KCl.....	0.006
Na.....	8.863	NaCl.....	22.533
Ca.....	0.718	CaCl ₂	
Mg.....	0.240	MgCl ₂	0.934
Fe & Al.....	0.006	MgBr ₂	0.031
SO ₄	1.732	CaSO ₄	2.441
Cl.....	14.800	Na ₂ SO ₄	0.013
Br.....	0.027	Fe & Al.....	0.006
I.....	Nil		

Analyst, Dr. J. T. Donald.

This spring is situated about 3½ miles to S. W. of Camperville, on the steep bank of Pine creek; and the over-flow from the spring flows directly into the creek. See Fig. 15.

Mr. Tyrrell, in his explorations in this district, examined a brine spring at the mouth of Pine creek, near Camperville. This spring most likely is from the same source as Springs H and I.

Saline Spring J. (Monkman's).

Approximate location.—Section 21—Township 18—Range 32 west of the Principal Meridian.

Temperature.—Atmosphere 47° F. (raining). Brine 45° F.

Specific Gravity (taken in field).—1.020.

Degrees of salinity.—(by salinometer in field).—15°.

Flow per minute.—No flow visible.

Approximate areas.—Salt flats 50 acres.—Prairie land.

*Analysis.**Conventional Combinations.**Grammes per litre.*

	(1)	(2)		(1)	(2)		
	<i>J.¹</i>	<i>Tyrrell²</i>	<i>Tyrrell³</i>	<i>J.¹</i>	<i>Tyrrell²</i>	<i>Tyrrell³</i>	
K.....	0.045	0.359	0.167	KCl....	0.086	0.685	0.319
Na.....	15.181	7.447	16.820	NaCl...	38.183	18.941	42.780
Ca.....	0.976	0.847	1.245	CaCl ₂			0.608
Mg.....	0.504	0.239	0.496	MgCl ₂ ..	1.987	0.823	1.963
Fe & Al.	0.004			MgBr ₂ .	0.017		
SO ₄	2.695	2.156	2.462	CaSO ₄	3.318	2.880	3.488
Cl.....	20.650	12.326	27.739	Na ₂ SO ₄	0.522		
Br.....	0.015			Fe & Al.	0.004		
I.....	Nil			MgSO ₄		0.154	

These springs, situated about 12 miles to the north of the town of Winnipegosis, are probably the best known salt springs of the district. It was here that James Monkman carried on the manufacture of salt in the early days. In the descriptions of these springs already given earlier in this chapter it is stated that the brine was strong. The pits which were dug soon ceased to furnish this strong brine, and others were opened. This strong flow at the first opening of a pit was probably due to the leaching out of the salt already deposited in the surrounding sinter; and as soon as this local concentration was used up, the pits gave out, and reached a low degree of salinity. A number of the old wells and pits are still to be seen. See Fig. No. 16.

In this Winnipegosis district there are several other springs which are known to the local settlers and inhabitants, but these could not be visited in the time available.

The results of the analyses of the foregoing brines sampled by the writer, and the field data taken, have, with the object of affording easy reference and facilitating a comparison, the one with the other, been embodied in the following tables:—

¹Dr. J. T. Donald, analyst.

²F. G. Wait, analyst. (See Geol. Surv. Can., Vol. V, Pt. 2, p. 31R.)

F. G. Wait, analyst. (See Geol. Surv. Can., Vol. V, Pt. 2, p. 32R.)

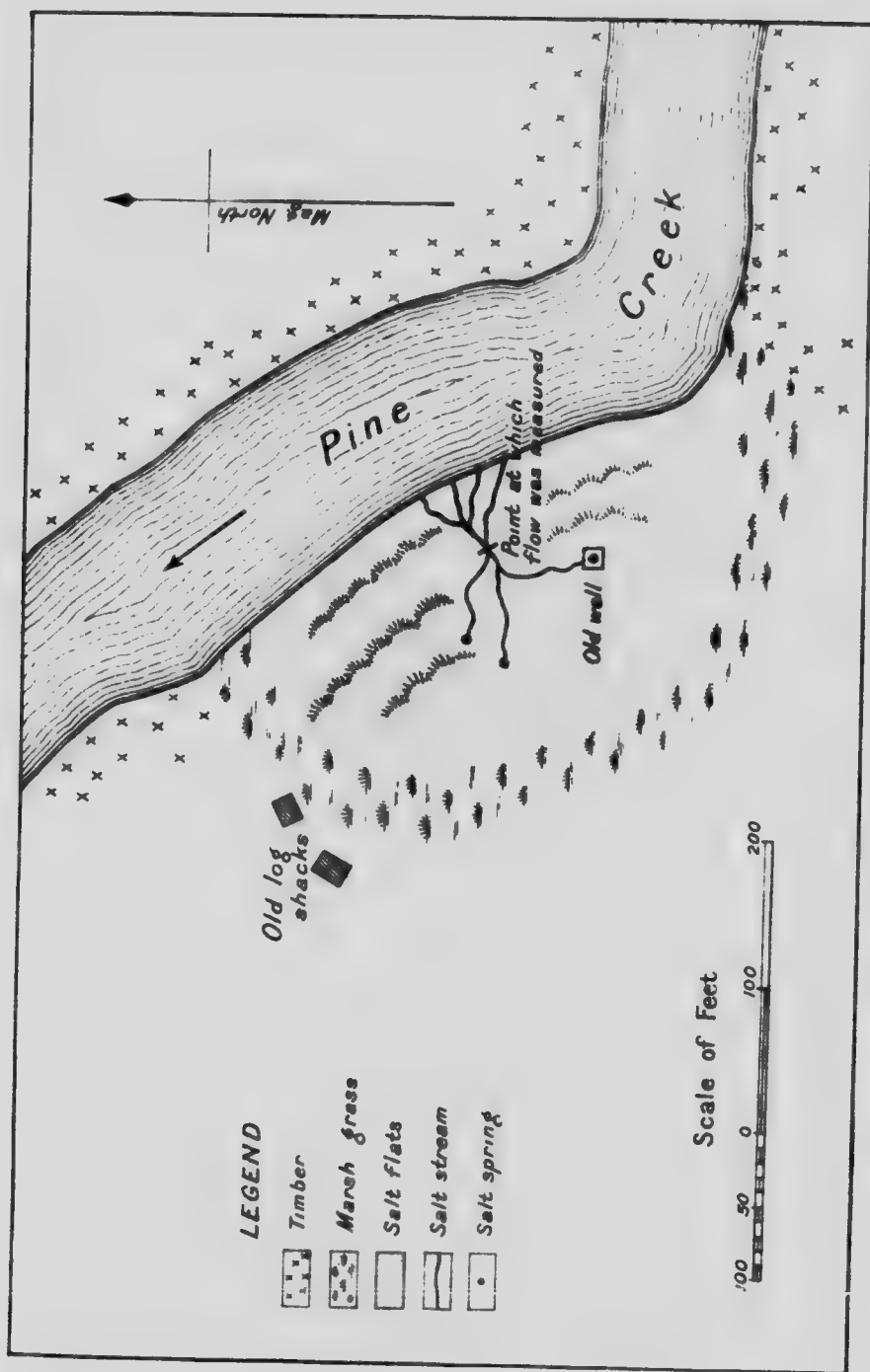


Fig. 15, Saline Spring I. About 3½ miles s.w. of Camperville, on Pine creek, Lake Winnipegosis, Manitoba.



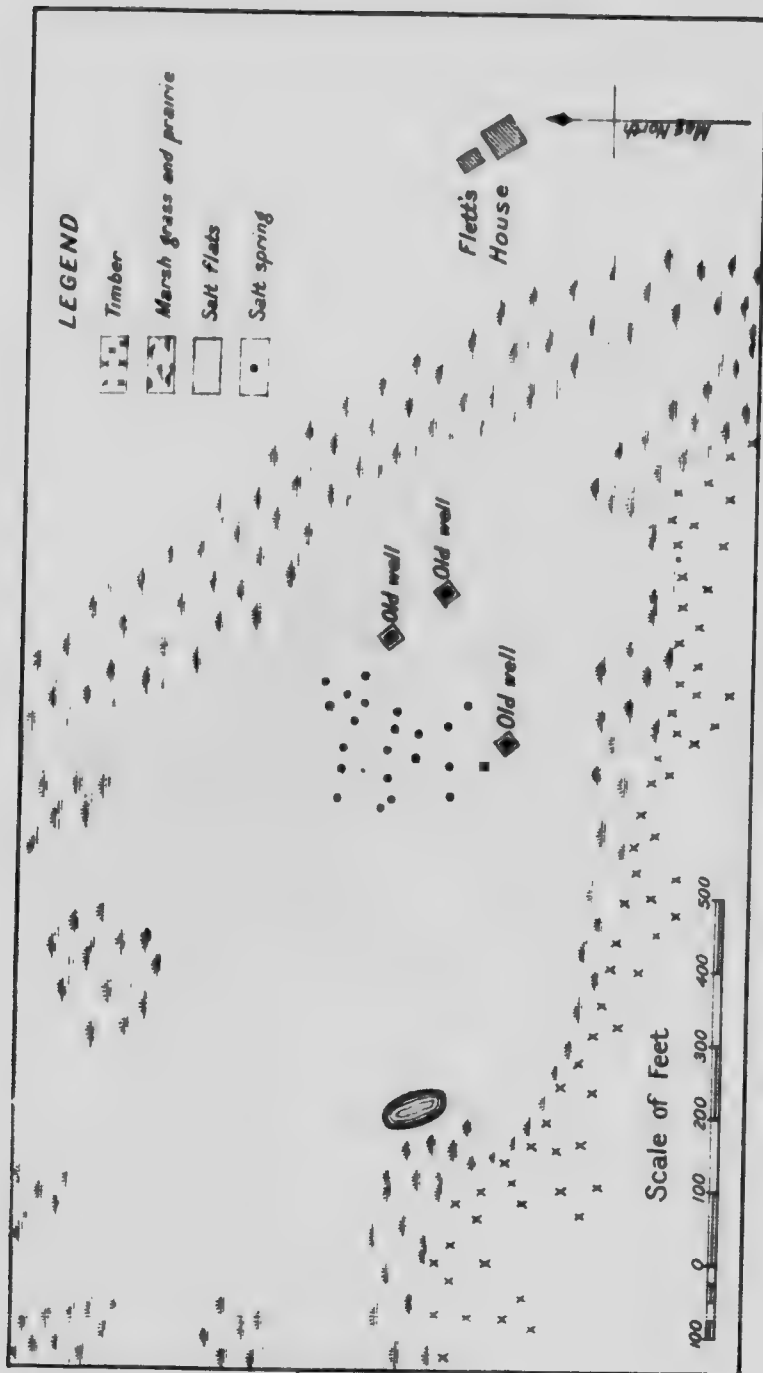


Fig. 16, Saline Spring J. On west shore of Lake Winnipegosis, 12 miles north of Winnipegosis.

TABLE No. IV.

Winnipegosis District—Brine Springs

Spring Letter	Approximate Location west of Principal Meridian			General Location Description.	Approximate area (acres)		Flow of Brine Imp. Gals per min.	Degree of Salinity	Remarks.
	Section	Township	Range		Salt Flat	Meadow.			
A.	33	24	43	To northwest of mouth of Bell river—Dawson bay—Lake Winnipegosis, Man.	30	7	17½	26°	About 15 springs are to be noticed in this area forming two streams which unite at end of meadow land and flow into Dawson bay.
B.	23	24	44	On west shore of Dawson bay about 1 mile south of Salt Point, Lake Winnipegosis, Man.	140	25	7½	26°	Numerous springs are to be found dotted over barren area. Only main flows could be measured. Probably 25% can be added to cover rest of flow.
C.	17	24	44	On south shore Dawson bay, 1 mile to east of mouth of Steeprock river, Lake Winnipegosis, Man.	16	2	45½	26°	Situated on sloping ground and brine flows directly into Dawson bay. Salt manufactured from this spring about 10 years ago for local use.
CC.	17	24	44	On south shore Dawson bay, Lake Winnipegosis, Man. About 300 yards to east of Salt Spring "C."	5	10	1½	26°	Probably a part of Spring C. Ground muddy and brine seeping out forming a small stream near lake edge where it was measured.
D.	11	25	44	On south bank of Steeprock river, about 1 mile from mouth, Dawson bay, Lake Winnipegosis, Man.	2	115	15½	12°	The greater part of this spring is boggy and covered with a thick growth of marsh grass through which the brine finds its way to the surface. Probably about 30% can be added to

Temp. of Atmosph
Temp. of Brine....
Specific Gravity...
Degree of Salinity.

K.....
Na.....
Ca.....
Mg.....
Fe and Al.....
SO₄.....
Si.....
Cl.....
Br.....
I.....

KCl.....
NaCl.....
CaCl₂.....
MgCl₂.....
MgBr₂.....
Na₂SO₄.....
CaSO₄.....
Fe and Al.....
Si.....

TABLE No. V.
WINNIPEGOSIS DISTRICT—SALINE SPRINGS.
Data taken in Field at Time Samples were taken

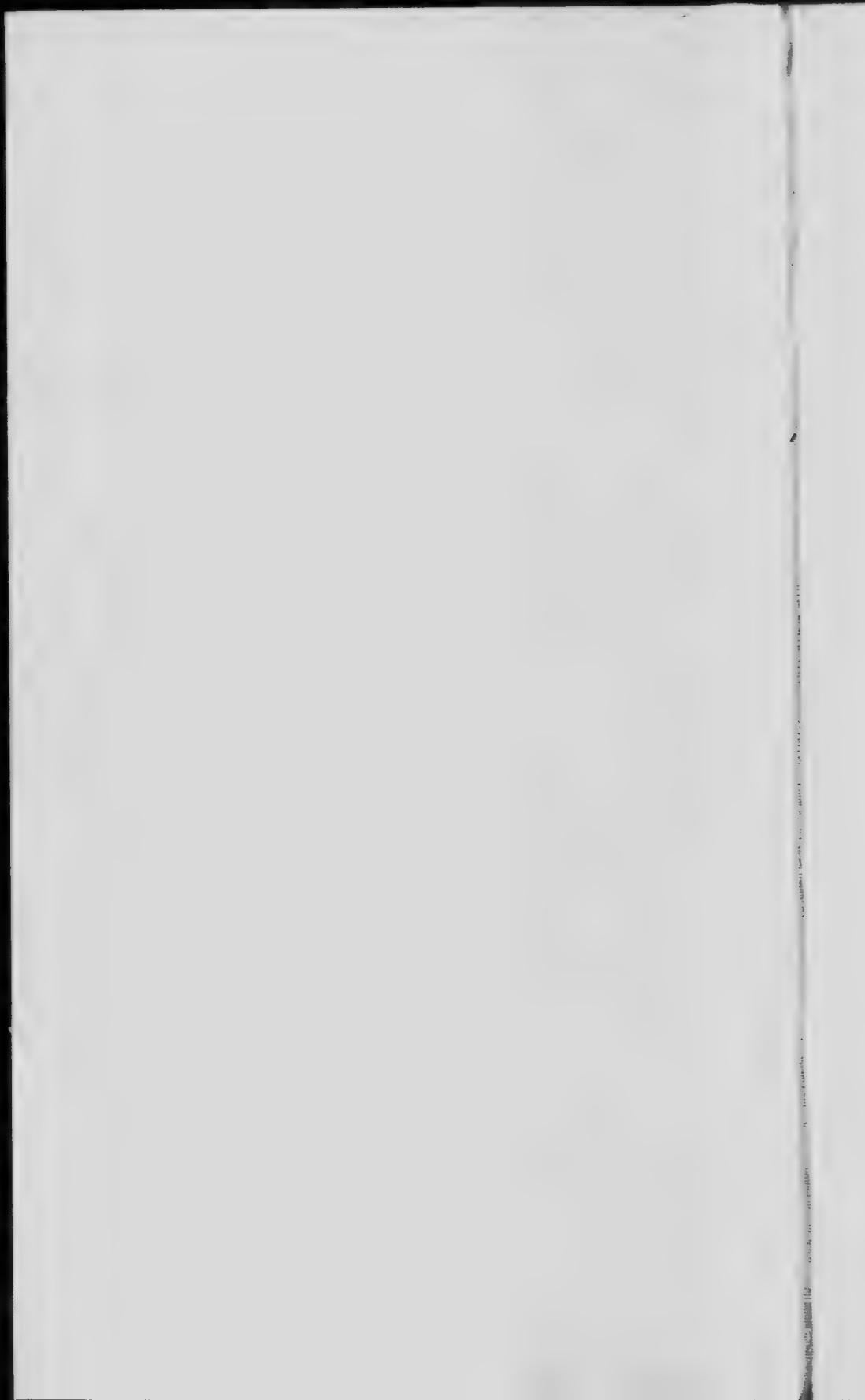
	A ₁	A ₂	B ₁	B ₂	C	D	F	G	H	I	J
Temp. of Atmosphere..	65°	65°	68°	68°	60°	61°	57°	76°	54°	51°	47°
Temp. of Brine.....	52°	54°	62°	44°	44°	60°	52°	42°	42°	42°	45°
Specific Gravity.....	1.035	1.030	1.030	1.040	1.040	1.020	1.030	1.035	1.025	1.015	1.020
Degree of Salinity.....	26°	25°	26°	25°	26°	12°	21°	24°	15°	10°	15°

Analyses.

K.....	0.095	0.136	0.352	0.231	0.113	0.009	0.011	0.006	0.071	0.003	0.045
Na.....	20.710	18.529	22.191	21.629	20.406	10.223	18.716	19.413	12.107	8.863	15.181
Ca.....	1.325	1.159	1.424	1.443	1.200	0.600	1.134	1.185	0.355	0.718	0.976
Mg.....	0.316	0.301	0.351	0.345	0.304	0.195	0.343	0.329	0.212	0.240	0.504
Fe and Al.....	0.006	0.005	Traces	0.003	0.110	0.009	0.004	0.005	0.006	0.006	0.004
SO ₄	3.085	2.749	3.229	3.243	2.993	1.646	2.600	2.678	2.123	1.732	2.695
Si.....	0.004	0.004	0.002	0.009	0.004	.....	.....	.....	.....	.....	.....
Cl.....	34.240	30.460	35.620	35.280	34.240	16.340	29.080	29.600	18.240	14.800	20.650
Br.....	0.108	0.056	0.107	0.080	0.041	Traces	0.015	0.022	0.018	0.027	0.015
I.....	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.

Conventional Combinations.

KCl.....	0.181	0.259	0.672	0.441	0.216	0.017	0.021	0.011	0.135	0.006	0.086
NaCl.....	52.675	47.127	56.440	54.020	51.765	25.750	47.604	49.377	30.707	22.533	38.183
CaCl ₂	0.110	0.039	0.224	0.258	.....	.....	0.142	0.191	.....	.....	.....
MgCl ₂	1.188	1.160	1.226	1.318	1.180	0.772	1.350	1.261	0.827	0.934	1.987
MgBr ₂	0.124	0.064	0.123	0.092	0.047	Traces	0.017	0.025	0.021	0.031	0.017
Na ₂ SO ₄.....	.....	.....	.....	.....	0.167	0.305	.....	.....	0.105	0.013	0.522
CaSO ₄	4.370	3.894	4.572	4.593	4.080	2.040	3.683	3.794	2.907	2.441	3.318
Fe and Al.....	0.006	0.005	Traces	0.003	0.110	0.009	0.004	0.005	0.006	0.006	0.004
Si.....	0.004	0.004	0.002	0.009	0.004	.....	.....	.....	.....	.....	.....



It is interesting to note, on comparison of the few analyses of springs by Mr. Tyrrell with the analyses of the same springs sampled by the writer, that in all cases the amount of potassium in the later samples is considerably less, while there appears to be a small increase in the amount of sodium present. The rainfall 25 years ago was a little less than last year.

WESTBOURNE DISTRICT.

The region included, tentatively, in this report, covers the area lying to the west of Portage la Prairie and the western boundary of Manitoba and south of the town of Dauphin. In this district several saline areas occur, and a number of drill holes have encountered saline waters.

The vicinity around the south end of Lake Manitoba is very marshy, and the water in the swampy land is, in some cases, distinctly saline to the taste.

At Gladstone, Man., saline waters are encountered in wells at a depth of from 160 to 170 feet. The waters from two of these wells were sampled and analysed.

Well K (on the farm of Tom Smith).

On this farm, situated one mile to the north of the town of Gladstone, a well has been sunk to the depth of 160 feet, and has been abandoned on account of saline water being encountered. It was hoped to obtain a good supply of drinking water. The water obtained is quite saline to the taste. When the water is first pumped it contains considerable air which however, rapidly passes off when allowed to stand. The temperature of the brine was 45° F. A sample was taken of this water which analysed as follows:—

<i>Analysis</i>		<i>Conventional Combination.</i>	
	<i>Grammes per litre</i>		
K.....	Trace	KCl.....	Trace
Na.....	7.535	NaCl.....	19.147
Ca.....	1.102	CaCl ₂	
Mg.....	0.602	MgCl ₂	2.367
Fe & Al.....	0.001	MgBr ₂	0.017
SO ₄	2.659	MgI ₂	0.012
Cl.....	12.390	CaSO ₄	3.747
Br.....	0.015	Na ₂ SO ₄	0.021
I.....	0.011	Fe & Al.....	0.001

Analyst, Dr. J. T. Donald.

Well L (on the farm of James McBride).

This farm, on the east side of the road $1\frac{1}{2}$ miles to the north of the town of Gladstone, has an abandoned well 165 feet deep, the water in which is distinctly saline. The water in the well rises to within 6 feet of the surface, and is covered with a scum. The water when sampled and placed in a bottle had a decidedly turbid appearance, which disappeared, however, on being allowed to stand. The sample analysed as follows:—

<i>Analysis</i>		<i>Conventional Combination.</i>	
<i>Grammes per litre</i>			
K.....	Trace	KCl.....	Trace
Na.....	11.216	NaCl.....	28.528
Ca.....	1.451	CaCl ₂	0.663
Mg.....	1.036	MgCl ₂	4.026
Fe & Al.....	0.011	MgBr ₂	0.123
SO ₄	2.910	CaSO ₄	4.122
Cl.....	19.800	Na ₂ SO ₄	
Br.....	0.107	MgI ₂	0.031
I.....	0.028	Fe & Al.....	0.011

Analyst, Dr. J. T. Donald.

It is remarkable to note the high bromine and iodine contents in both these wells, hence the waters should be classed as mineral waters rather than brine. They bear a striking resemblance to well known mineral springs, and it is possible that this district may turn out to be a potential mineral water area analogous to the Caledonia Springs district in Ontario.

Westbourne Saline Spring (M)

Approximate location.—Section 10—Township 10—Range 14 west of the Principal Meridian.

Temperature.—Atmosphere 82° F. Brine 52°.

Flow per minute.— $36\frac{1}{4}$ gallons (imperial).

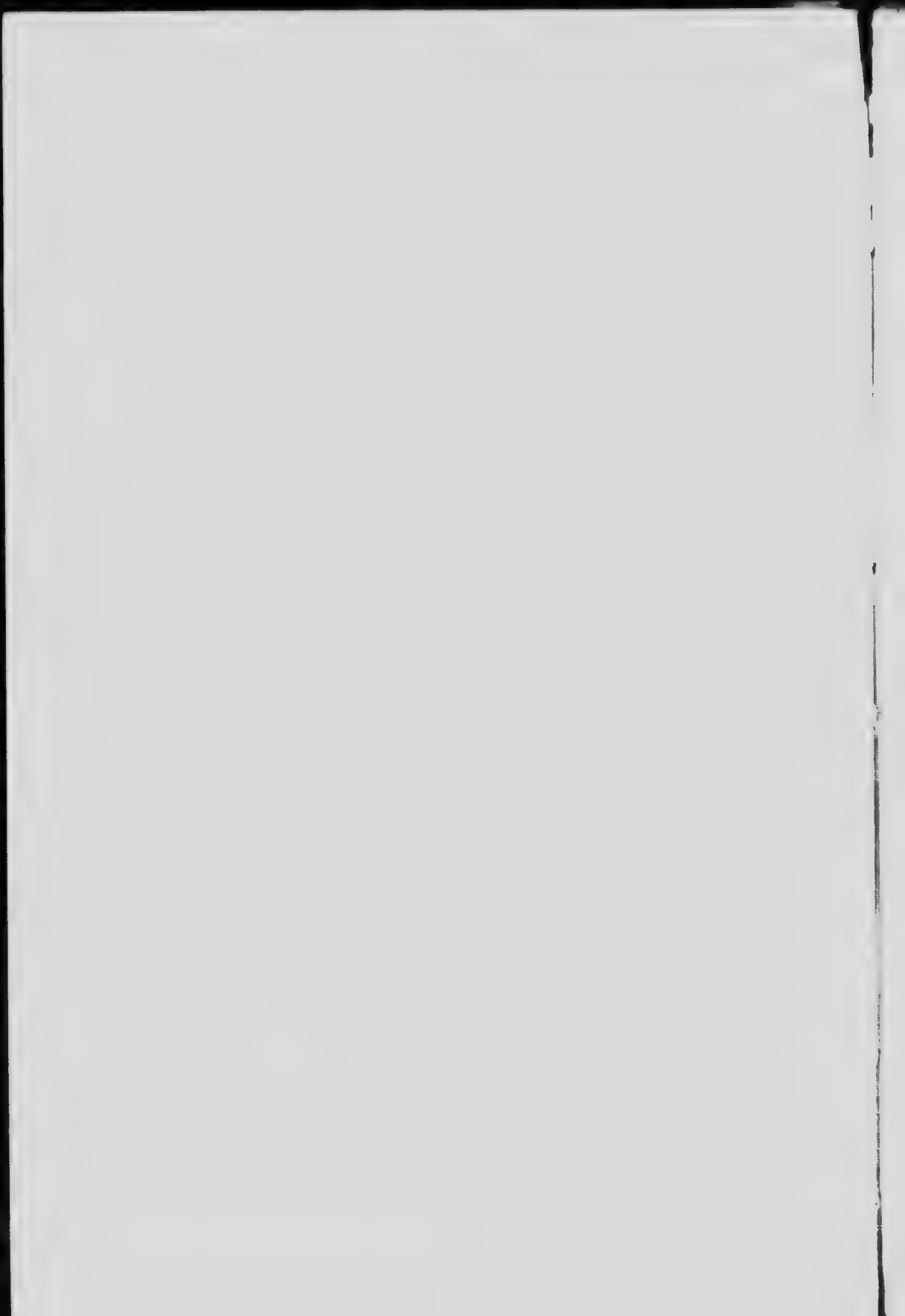
PLATE XVI.



A. Saline Pond M, Westbourne district, Westbourne, Manitoba.



B. General view of La Saline flats, looking northeast, Alberta.



*Analysis.**Conventional Combination.*

K.....	Trace	NaCl.....	7.791
Na.....	3.063	KCl.....	Trace
Ca.....	0.400	CaCl ₂	0.272
Mg.....	0.239	MgCl ₂	0.946
Fe & Al.....	0.014	MgBr ₂	Trace
SO ₄	0.725	CaSO ₄	1.027
Cl.....	5.330	Fe & Al.....	0.014
Br.....	Traces		
I.....	Nil		

About 7 miles west of Westbourne, a station on the Yorkton branch of the Canadian Pacific Railway, on the north bank of the White Mud river, a mile to the south of mileage 23 west of Portage la Prairie, a saline spring comes to the surface. (See Plate XVI A.). For several square miles to the north of this spring, the prairie is only sparsely covered with grass. Many patches are altogether bare, and the red salt plant and the characteristic surface deposits of alkali are found. Locally this district is known as the Salt flats. The White Mud river occupies a depression varying in width, in the surrounding plain and it is in one of the wider portions of this depression that the saline spring finds its way to the surface. The spring, rising in marshy ground, consists of a pool about 50 feet long by 20 feet wide, in which the brine is constantly bubbling up. Surrounding this pool several smaller springs rise in the marshy flat. A small channel, about 200 feet in length, carries the overflow into the river. (See Fig. 17).

As will be seen from the analysis given above, the brine from this spring is too weak in sodium chloride to be operated commercially in the production of salt.

About 40 years ago the Indians and local settlers of the district manufactured salt for farm use and home consumption from this spring, but the advent of the railway, and the easier shipping facilities from the east caused operations to be suspended.

Near the water tank of the Canadian Pacific Railway, at Westbourne station, a well sunk to a depth of 90 feet, was abandoned on account of alkaline water being encountered.

Government Well, Neepawa, Man. (O).

Approximate Location.—Section 33—Township 15—Range 14 west of the Principal Meridian.

<i>Analysis.</i>		<i>Conventional Combination.</i>	
K.....	0.016	NaCl.....	181.528
Na.....	71.370	KCl.....	.031
Ca.....	4.096	CaCl ₂	8.042
Mg.....	1.188	MgCl ₂	4.603
Fe & Al.....	Traces	MgBr ₂	0.110
SO ₄	2.875	CaSO ₄	4.073
Cl.....	111.240	Fe & Al.....	Traces
Br.....	0.096	MgI ₂	0.016
I.....	0.015		

The government of Manitoba, in drilling a well for gas, about 200 yards from the Canadian Pacific Railway station, at Neepawa, encountered two flows of strong brine at depths of 1,225 feet and 1,455 feet. When the well was visited by the writer on September 27, 1913, the drill had reached a depth of 1,525 feet, and the brine from the second flow was still obtainable, and the sample, of which the above is an analysis, was obtained. On examining the cuttings from this hole, numerous chipings of gypsum were obtained. These, the driller told me, came from a depth of about 650 feet.

This brine, although high in calcium chloride and calcium sulphate, contained the highest sodium chloride (common salt) content of any spring examined in Manitoba. The total solid content was 190.896 grammes in a litre. It is interesting to note the presence of iodine and bromine in this sample.

WINNIPEG DISTRICT.

A syndicate of Winnipeg men have drilled 7 wells in the district within a radius of 20 miles of the city of Winnipeg and in five of them they encountered water of a more or less

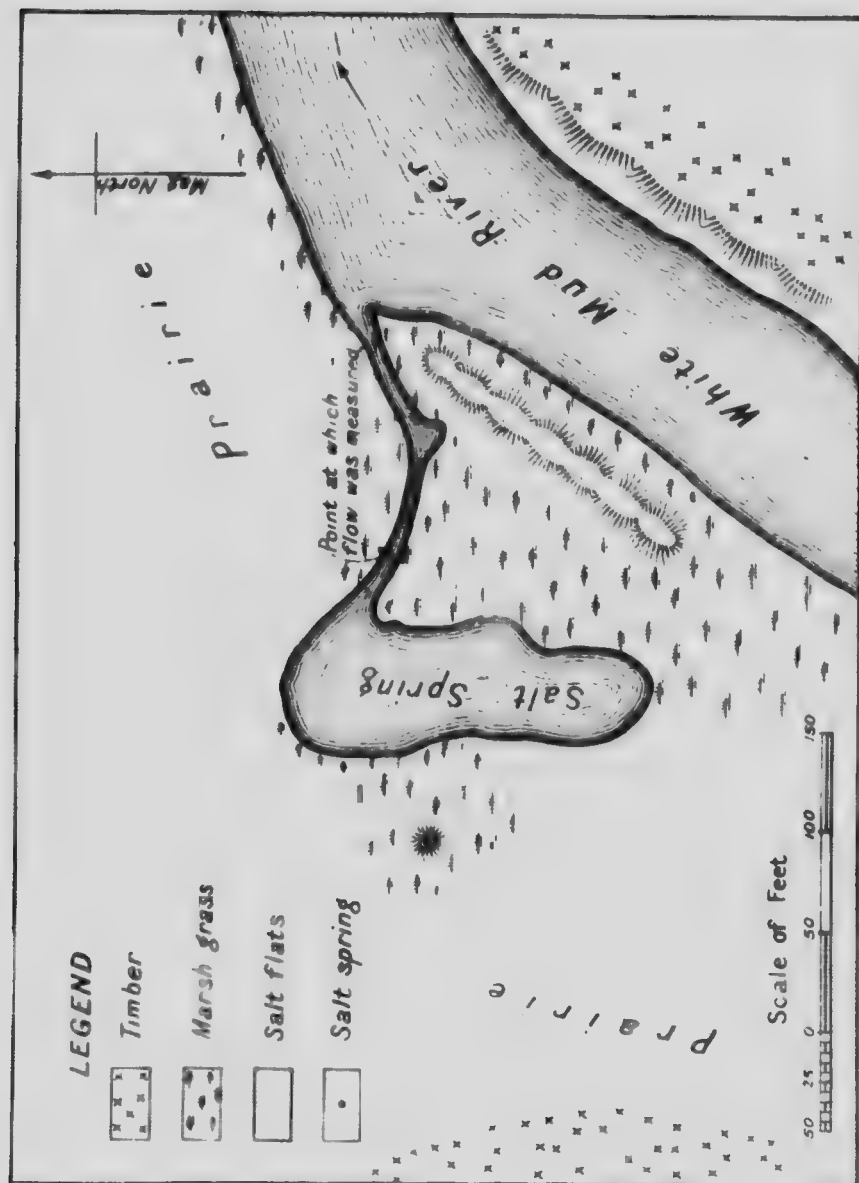


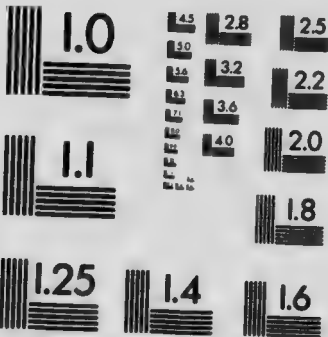
Fig. 17, Saline Spring M. Westbourne, Manitoba.





MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE Inc

1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax



degree of salinity. It was noted by the drillers, that whenever a certain kind of coarse white sandstone was drilled into, water was encountered. Mr. E. F. Hutchings, one of the principal movers in this drilling syndicate, furnished me with the following logs of two holes drilled by them.

Log of Well (8 miles northeast of Winnipeg on farm of Mr. E. F. Hutchings).

<i>Material encountered.</i>	<i>Feet.</i>	<i>Probable Age.</i>
Sand and gravel.....	14	
Blue clay.....	14	
Hard pan.....	2	Post glacial.
Sand-gravel and boulders.....	90	
Hard limestone rock.....	15	
Water seam honeycomb.....	5	
Free limestone.....	60	
Flinty limestone.....	40	
Blue limestone.....	20	
Grey limestone.....	30	
Water seam cracks.....	5	Ordovician ? Limestone
Soft limestone.....	30	
Flinty limestone.....	20	
Brown limestone.....	15	
Blue (hard) limestone.....	30	
Grey (hard) limestone.....	30	
Broken (hard) limestone.....	10	
Flinty mixed with shale.....	16	
Blue shale.....	20	
Mottled shale.....	10	Ordovician Sandstone ?
White clay ? a shale.....	8	
Soapstone ? or blue clay.....	2	
Shale.....	9	
Salt rock ? (salt water in sandstone).....	28	

523 feet.

Log of Well (drilled by syndicate at Elmwood).

<i>Material encountered.</i>	<i>Feet.</i>	<i>Probable Age.</i>
Blue clay.....	55	}..... Post Glacial.....
Hard pan and gravel.....	15	
Brown limestone.....	90	
White limestone.....	85	
Brown limestone.....	202	Ordovician Limestone.
Shale.....	8	
White sandstone (salt water).....	22	
Blue shale.....	20	
Black shale.....	5	Ordovician Sandstone.
Blue shale.....	45	
White sandstone (salt water).....	20	
Red sandstone and quartz.....	1	
Granite.....	2	Archæan.

 570 feet

The water from the well drilled by this syndicate in Elmwood, Winnipeg, is being employed by the Winnipeg Mineral Springs Sanitarium for mineral water baths, as a cure for numerous muscular diseases. The water after being charged with CO_2 and bottled, is being put on the market in the west as a table mineral water. A sample of the water, as it flowed from the well, was taken by the writer, and analysed with the following results:—

<i>Conventional Combination.</i>			
K.....	0.006	KCl.....	0.011
Na.....	11.554	NaCl.....	28.785
Ca.....	0.616	CaCl_2	
Mg.....	0.126	MgCl_2	0.491
Fe & Al.....	0.003	MgBr_2	0.013
SO_4	1.972	CaSO_4	2.094
Cl.....	17.720	Na_2SO_4	0.731
Br.....	0.011	Fe & Al.....	0.003
I.....	Nil	Si.....	

Analyst, Dr. J. T. Donald.

In making the statement that at the present time there is small hope that common salt could be manufactured commercially from any of these springs (with the possible exception of the Neepawa well O) there are several points which have to be taken into consideration, and which modify this statement to some extent.

(1) Most of the springs are in the north country, and at present are inaccessible to transportation, and for many years to come will be too far from available markets to be successfully operated.

(2) In all cases, with the one exception above stated, the brines are all too weak NaCl to be evaporated economically. The cost of fuel to operate evaporators on such weak brines would be prohibitive.

(3) The quantity of brine available is not, at the present, sufficient, and the supply is not constant. This might be remedied by boreholes in the vicinity of the springs, and thus both increasing as well as regulating the supply, but the brine thus obtained might, in consequence of the extra drain, be greatly weakened.

(4) In several of the brines the impurities are high. This might possibly be an advantage if present in sufficient quantity to recover as by-products. In this line it is interesting to note that bromine and iodine are present in several of the samples taken.

(5) The question arises whether there are any means by which these weak brines could be concentrated. There certainly is this possibility, and if a constant and sufficient supply of brine were assured, solar evaporation might possibly afford a sufficient concentration, so that the final evaporation could be carried on economically by one or other of the artificial heat methods described in the chapter on technology. If this method were employed, the cost of lumber would be a serious item to take into account. A possible combination of the solar method in summer, and the freezing or congelation method by winter, might well be operated.

I desire to give an idea as to whether the climatic conditions are suitable to these natural methods of concentration, the following tables—kindly furnished by Prof. Stupart of the

TABLE VIII.
Mean Temperature at Swan River, Man.

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1908.....	-11.0	-3.3	18.3	24.6	53.1	57.4	66.0	59.6	54.7	40.0	25.2	5.6	
1909.....					50.9	59.7	65.3	63.9	56.8	39.7	18.3	-0.1	
1910.....	5.6	-0.6	32.4	39.2	46.7	61.1	65	58.7	49.9	42.4	17.3	4.5	

TABLE IX.
Mean Temperature at Dauphin, Man.

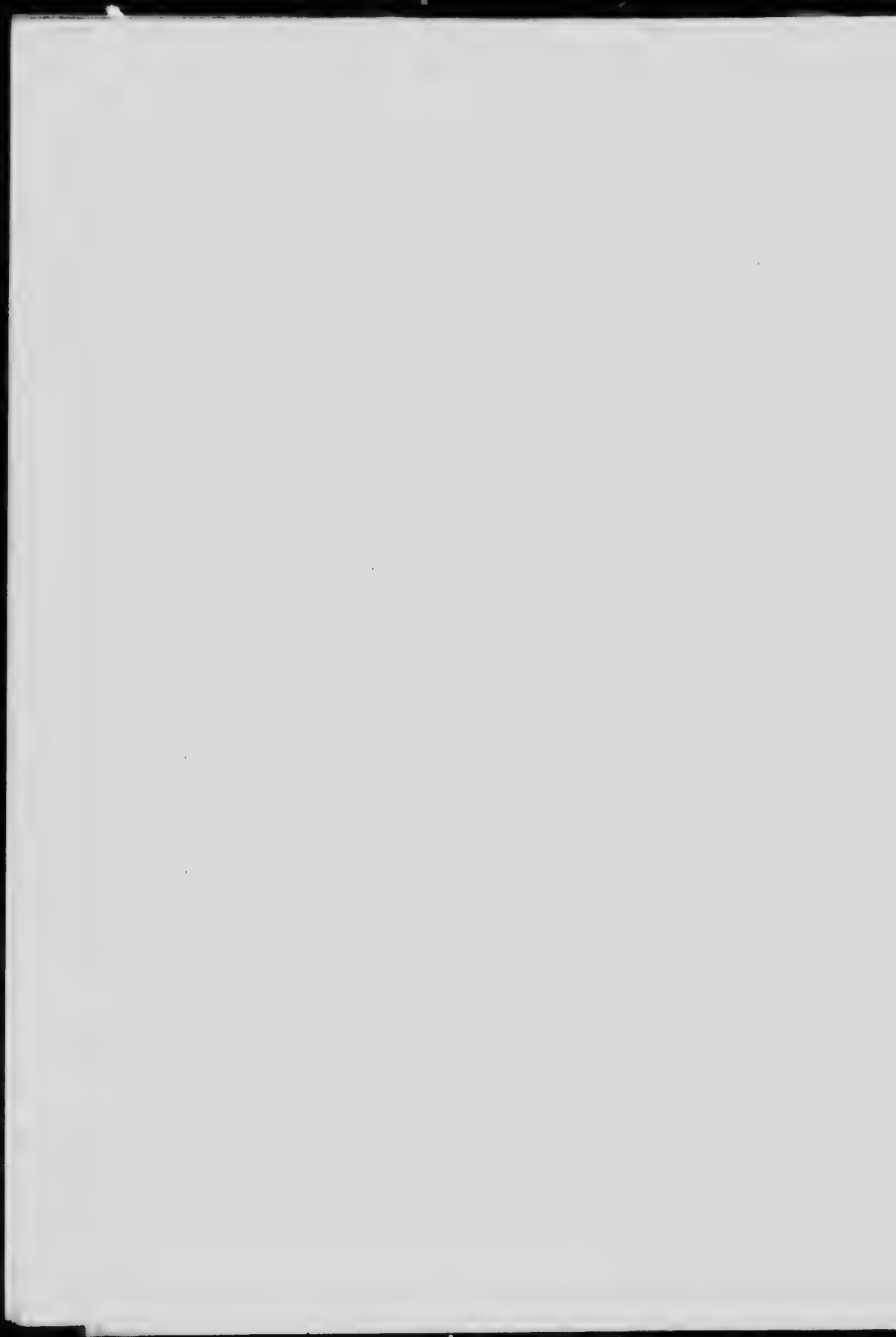
	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
1890.....		7.97	9.03			59.13	64.45	64.65	59.32				
1891.....			16.3	37.1	51.0	61.3	63.5	60.8	48.1	44.6	20.3	7.5	
1903.....	1.9	6.0	11.1	33.2	51.8	59.7	62.5	59.9	50.7	41.9	30.9	6.2	
1904.....	-1.3	-7.8	11.1	33.2	51.8	59.7	62.5	59.9	50.7	41.9	30.9	6.2	
1905.....	-57	3.3	22.0	38.6	49.6	57.8	65.4	65.7	54.1	35.1	27.0	12.3	
1906.....	6.2	2.3	18.5	46.6	46.9	63.8	67.3	64.6	57.7	41.7	23.7	-0.3	
1907.....	-12.6		18.7	27.8	36.1	59.7	65.4	59.4	47.8	43.5	25.5	12.4	

TABLE VI.

Swan River, Manitoba

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
<i>Rainfall (in inches).</i>													
1908.....	—	—	—	—	0.90	4.96	0.72	2.05	0.31	0.85	—	—	—
1909.....	0.00	0.00	—	—	0.73	2.21	3.67	2.57	0.49	0.49	0.80	—	—
1910.....	0.00	0.00	0.00	0.76	2.20	3.17	1.30	4.47	0.79	0.22	0.00	0.00	12.91
1911.....	0.00	—	—	0.31	2.66	3.52	2.64	3.68	2.37	0.99	0.00	0.00	—
1912.....	0.00	0.00	—	—	—	—	—	—	—	—	—	—	—
<i>Snowfall (in inches).</i>													
1908.....	—	—	—	—	—	—	—	—	flurry	0.0	—	—	—
1909.....	—	—	—	—	1.0	—	—	—	0.0	4.0	—	—	—
1910.....	0.5	5.0	4.5	11.0	4.3	—	—	—	0.0	0.0	7.5	13.0	45.8
1911.....	7.0	—	—	0.0	3.0	—	—	—	0.0	1.3	14.0	12.0	—
1912.....	2.0	3.0	—	—	—	—	—	—	—	—	—	—	—

Note:—Rainfall and snowfall averages given above are derived from too short a period to be trustworthy.



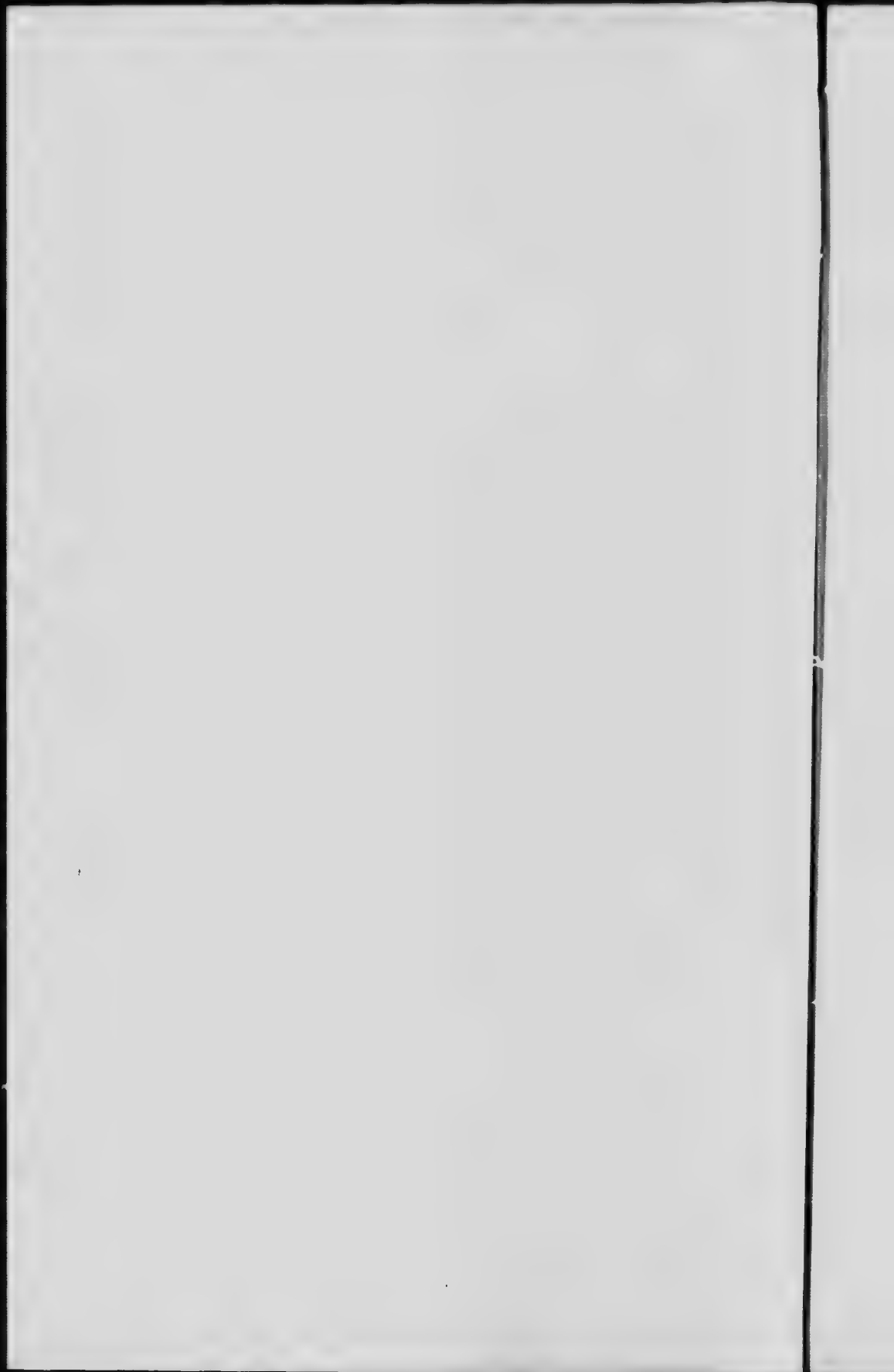
Year.	Jan.
1903.....	
1904.....	
1905.....	
1906.....	
1907.....	0.00
1910.....	
1911.....	
1912.....	
1913.....	0.00
1903.....	
1904.....	No rec
1905.....	
1906.....	
.....	9.0
.....	
1912.....	
1913.....	12.0

Note.—Averages given

TABLE VII.
Dauphin, Man.

Year.	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
<i>Rain fall.</i>													
1903..					4.62	1.97	3.64	2.19	1.92	0.86			
1904..					0.00	2.06	2.43	1.26	1.58				
1905..				R.	3.10	1.52	1.93	1.34	3.08	1.30	2.85		
1906..					3.53	6.17	3.62	2.99	1.03	0.00	0.00		
1907..	0.00		0.00	0.00	0.99	2.08	2.83	6.79	1.13	0.70	0.00	0.00	
1910..													0.00
1911..					4.69	1.60	2.36	3.18	2.45	1.65			0.00
1912..			0.00	0.10	2.00	2.03	6.01	2.54	6.95	0.50			0.00
1913..	0.00	0.00	0.00	0.00	0.53	2.19	4.11	2.05	1.10	0.12	0.00	0.00	10.07
<i>Snowfall.</i>													
1903..					0.0				7.0				
1904..	No records kept of snow in 1904.												
1905..				2.0	1.0				0.0	2.0			
1906..					0.0				0.0	0.0	31.5	3.0	
1907..	9.0		6.0	0.0	0.0				0.0	0.0	2.0	9.0	
1910..													11.0
1911..					2.0				0.0	0.0			6.0
1912..			3.0	2.0	0.0				0.0	0.0			8.0
1913..	12.0	14.0	4.0	0.0	0.0				0.0	S	6.0	S	

Note.—Averages given above have been derived from too short a period to be trustworthy



Dominion Meteorological Observatory, Toronto—give, for the last five years, the average temperatures and rain and snowfall at the recording stations of Swan River and Dauphin, Man.

From these tables it will be seen that it is possible that the summer would be sufficiently dry and warm to employ the solar method effectively, and there would be no question but that during the winter months the temperature would be sufficient to apply the freezing method. The fact also that there is, generally, a steady breeze in Manitoba, would materially assist in the concentration.

Owing to the Ontario salt district being situated close to lake navigation, and to the great purity and strength of the brines, the producers from this district are enabled to place their product in the western market at a fairly low price.

Any salt manufactured in Manitoba would naturally have this supply to compete with. The following table gives the price of salt products in Winnipeg shipped from the Michigan-Ontario district, during September, 1913. From this table one can judge how cheaply the salt would have to be produced from the Manitoba brines, in order to compete successfully with the eastern product.

TABLE X.

Salt.

Bags or boxes (Third class freight L.C.L.)	
Sacks or barrels (Fourth class freight L.C.L.)	
Common, fine, per bbl.	2.02
Common, coarse, per bbl.	2.12
Common, fine in 50 lb. jute sacks, each.	.42
Extra coarse, per bbl.	2.15
Factory filled in 50 lb. duck bags, each.	.53
Table, 100-3-lb. bags, per bbl.	3.45
Table, 60-5-lb. bags, per bbl.	3.40
Shaker per case of 2 doz.	1.75
Purity " "	1.70
Regal " "	1.75
Rock, in 200 lb. bags, per lb.	.01
Rock, crushed in 200 lb. bags, per lb.	.01

CAR LOTS F.O.B. FORT WILLIAM OR PORT ARTHUR. MINIMUM
CAR 30,000 LBS.

Common fine, per bbl.....	1.10
Common coarse, per bbl.....	1.20
Common fine, 50 lb. jute sacks, per sack.....	.26
Extra coarse, per bbl.....	1.25
Factory filled, 50 lb. duck sacks, per sack.....	.34
Table 100 3 lb. bags, per bbl.....	2.50
Table 60 5 lb. per bbl.....	2.45
Rock, in 200 lb. bags, per ton.....	12.00
Rock crushed, in 200 lb. bags, per ton.....	10.00

CHAPTER VI.

SALT OCCURRENCES IN SASKATCHEWAN, ALBERTA,
AND NORTHWEST TERRITORIES.

In the prairie provinces of Saskatchewan and Alberta, numerous saline springs are known to occur. Up to the present time, however, these have not been economically important, owing to their inaccessibility to ready markets. Moreover, very little is known about them, and so far no definite attempt has been made to prospect for rock salt in place. Since the springs occur over such a wide area, it is possible that stronger brines, and more favourably situated localities may yet be found, and there is always the possibility of finding beds of the mineral in place, near the surface. The Mackenzie basin, in which all the springs at present known occur, is lacking at the present time in railway transportation. As soon as this deficiency is remedied, it is altogether likely that this district will become a salt producer, and furnish this necessary article of consumption to the prairie provinces. In order to give an idea of some of these saline areas some of the more important localities are here described.

Northern Alberta Exploration Company.

The Northern Alberta Exploration Co. have, since 1907, been carrying on drilling operations for oil in the vicinity of McMurray, Alberta. Two wells have been sunk in both of which they claim to have encountered rock salt or salt-bearing formation. The first hole has been drilled to a depth of 1,475 feet, while the second reached a depth of 1,406 feet. The holes are 155 feet apart, and, according to the logs of the wells, show the same formations in each hole. The accompanying sketch (Fig. 18) of the logs of the wells was kindly furnished by Mr. O. S. Finnie, Inspecting Engineer, Department of the Interior.

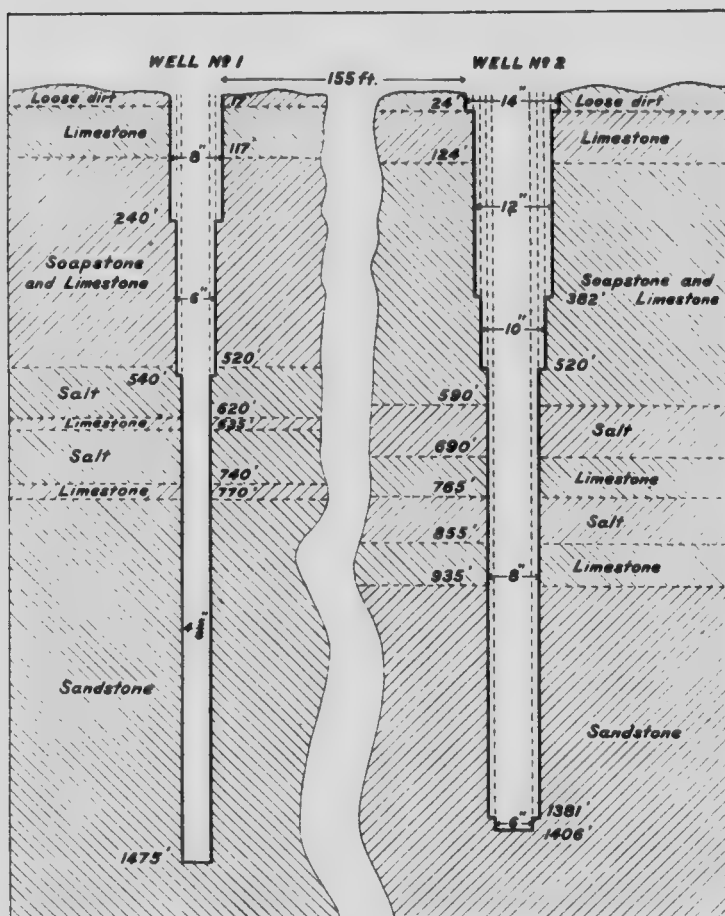


Fig. 18. Logs of wells sunk by Northern Alberta Exploration Co., McMurray, Alberta.

Note.—The dotted lines shown on inside of wells indicate the amount of casing used. This casing is still in place, where it will remain for the purpose of preserving the wells.

LA SALINE.

At La Saline, 26 miles north of Ft. McMurray numerous saline springs have from time to time been noted by the several explorers of the district. Mr. Sydney C. Ells, of the Mines Branch, while examining the tar sands of the district during last summer (1913) made the following notes on the occurrence of these saline springs:—

The occurrence of saline springs has long been recognized in many parts of the Athabaska-Mackenzie basin. Throughout this area Devonian sediments have a wide distribution, and probably constitute the origin from which, for the most part, the Springs derive their mineral matter. Logs of wells drilled through the Devonian near McMurray¹ record the presence of very considerable beds of salt, while other wells² north of McMurray and on both banks of the Athabaska discharge quantities of saline water. Within a radius of seventy-five miles of McMurray, saline springs have been recognized on the Wabiskaw, Firebag, Christina, and other streams. The water from these springs is usually clear and bright.

The most important spring recognized in the McMurray district, occurs at Saline, 26 miles north of McMurray. See Fig. No. 19. At this point the eastern bank of the Athabaska valley swings away from the present shore line, the intervening area being now occupied by a typical clay flat several hundred acres in extent. In this flat the lake, known as La Saline, occurs. A trail 250 yards long leads from the Athabaska and meets the lake near its southern extremity.

At periods of high water, the lake itself is of considerable extent. During the driest seasons, however, only occasional large and shallow ponds remain (Plate XVIIIA). At such times it is possible to cut a considerable tonnage of marsh hay, particularly toward the north end of the flat (Plate XVIIIB). Along the eastern edge of the lake the ground rises rapidly in a series of narrow terraces to an elevation of quite 200 feet. Russell brook, a small fresh water stream, rises in the muskeg some two miles to the east and enters the flat near the southeastern corner. Along the creek sections of rubbly Devonian limestone are exposed and are overlaid by from 30 to 125 feet of bituminous sand. In places the limestones³ show traces of bitumen on the surface and along joint planes, evidently due to seepage from the overlying bituminous sands.

At the mouth of Russell brook, and on the south side, a number of small springs, of which four or five are at present active and of which the largest is probably 8 or 10 feet in diameter, rise through the limestone and overflow down the escarpment (Plate XVIIIB). The waters, in depositing their mineral matter, have formed a cone several feet in thickness and of considerable extent. Samples of the salts thus deposited, were taken at a number of points and gave the following results:—

¹Drilled by Northern Alberta Exploration Co., Ltd., at mouth of Horse Creek, 1 mile south of McMurray.

²Drilled on the eastern bank of the Athabaska river by Fort McKay Oil and Asphalt Co., Ltd., at Saline, by A. Von Hammerstein, on the western bank one half mile north of McKay, and by Athabaska Oils Ltd., 46 miles north of McMurray on the eastern bank.

³In the writer's opinion these cannot be classed as bituminous limestones.

	58	60	62
***Volatile.....	3.34	18.00	19.10
NaCl.....	1.78	1.07	Traces
SiO ₂	0.85	0.21	1.53
*CO ₂	38.32	4.70	0.00
**SO ₃	4.37	42.98	46.40
Fe ₂ O ₃	0.28	0.08	0.06
Al ₂ O ₃			
CaO.....	50.29	33.11	32.83
MgO.....	0.48	0.28	0.08
*Equivalent: CaCO ₃	87.09	10.68	0.99
** " CaSO ₄	7.43	73.07	78.88
" CaSO ₄ .2H ₂ O.....	9.40	92.41	98.90
***Loss on ignition other than CO ₂ .			

Dr. J. T. Donald, analyst.

"A sample of the water itself taken by Mr. R. G. McConnell¹ was examined by Mr. F. G. Wait with the following results:—

<i>Analysis.</i>	<i>Grammes per litre.</i>	<i>Hypothetical Combination.</i>
Potassium.....	0.868	Chloride of Potassium..... 1.655
Sodium.....	23.937	" " Sodium..... 60.893
Calcium.....	1.574	" " Magnesium..... 1.049
Magnesium.....	0.496	Sulphate of Lime..... 5.352
Sulphuric Acid (SO ₄).....	4.70?	" " Magnesia..... 1.155
Chlorine.....	38.451	

"There was not enough of the water at the disposal of the operator to admit of his examining it for any of the more rarely occurring constituents."

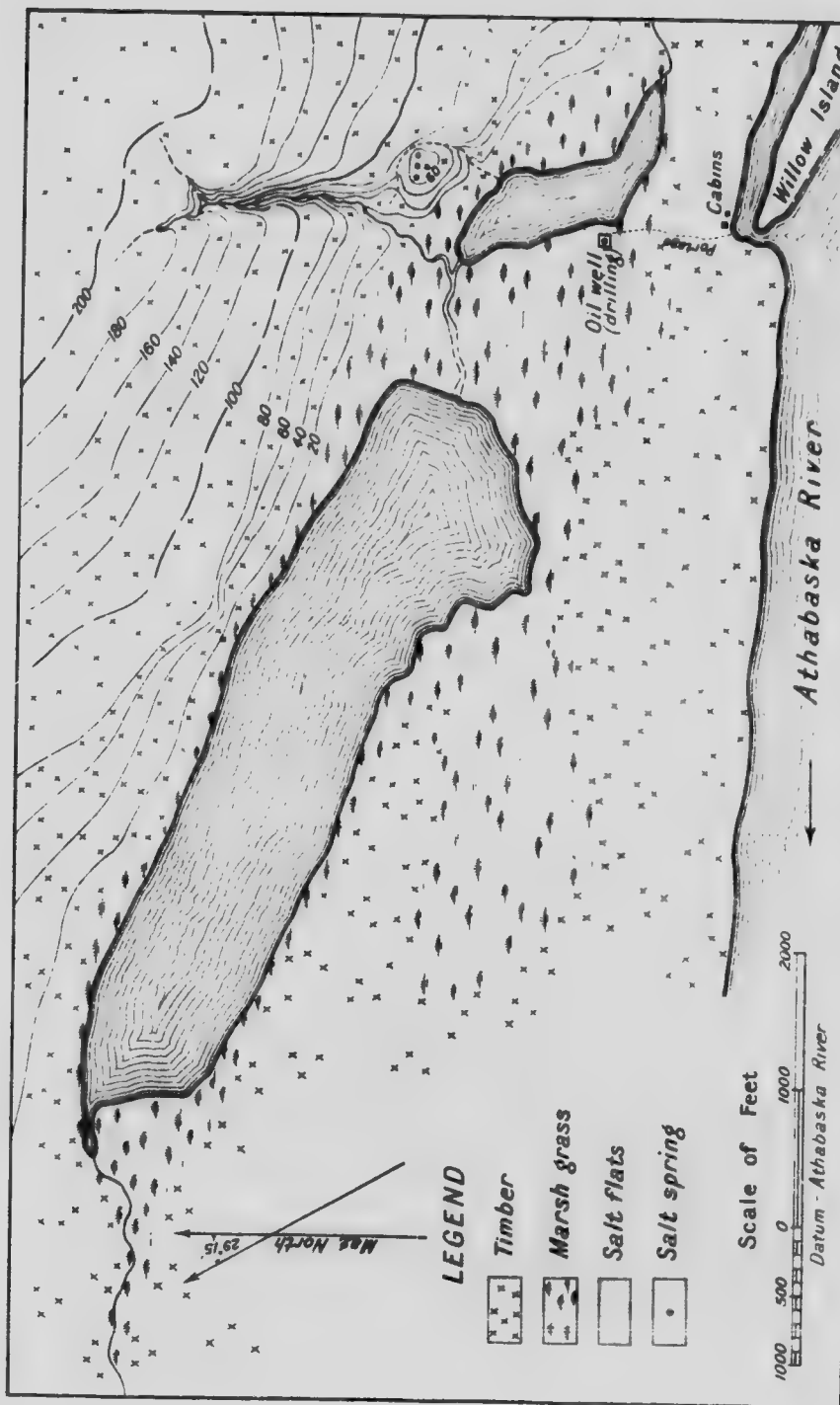
SALT RIVER, SLAVE RIVER DISTRICT, MACKENZIE BASIN.

One of the most strongly saline and perhaps the most noted of the saline spring areas in the Mackenzie basin is that occurring on the bank of Salt river which flows into Slave river about half way between Athabaska and Great Slave lakes. Referring to this stream and these springs, Sir J. Richardson writes²:—

The Salt river flows in from the westward, a short distance below the portages. We ascended it for twenty-two miles, including its windings, but not above half that distance in a straight line, for the purpose of visiting the salt springs from whence it derives its taste and name. Seven or eight copious saline springs issue from the base of a long even ridge about 600 feet high, and spreading their waters over an extensive clayey plain, deposit a

¹Geol. Surv. of Canada, Vol. VI, pp. 79-80R.

²Geol. Surv. Can., Vol. II, p. 14R.



Surveyed by S. C. Ellis, 1914

Fig. 19, La Saline lake, Athabasca river, Alberta.

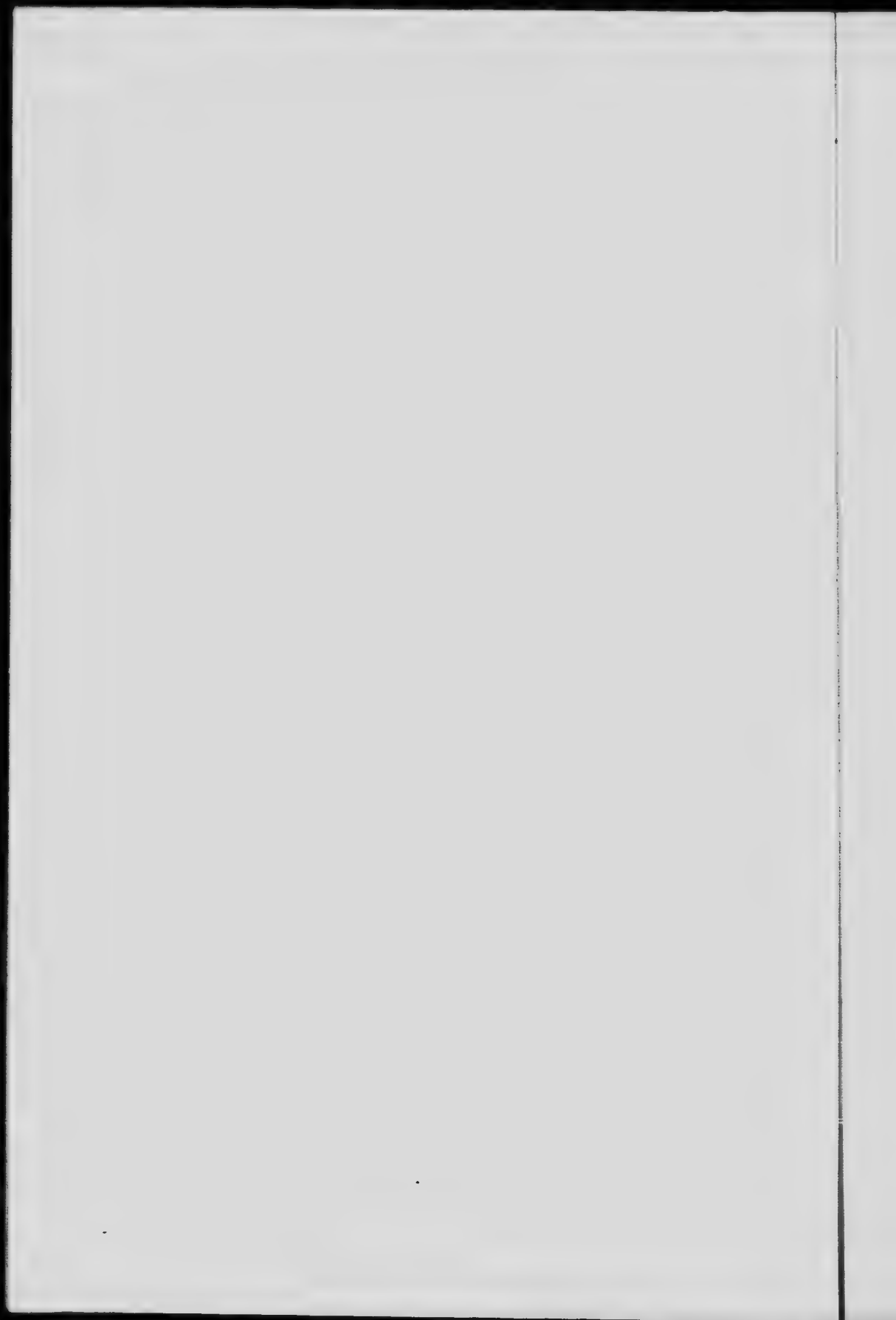
PLATE XVII.



A. View of La Saline flats, Alberta, looking north.



B. View of Devonian escarpment, near southeast corner of La Saline, Alberta, showing incrustations of various salts.



considerable quantity of very pure common salt in large cubical crystals. The *mother water*, flowing into the Salt river, gives it a very bitter taste, which it retains until near its junction with the Slave river when the addition of some fresh water streams renders it only slightly brackish. A few patches of greyish compact gypsum were exposed on the side of the ridge from whence the springs issue.

Sir J. Richardson visited these springs in the summer of 1820. Captain Back who accompanied him on that expedition again visited these springs in 1833. He notes¹ three springs, "varying in diameter from four to twelve feet, and producing hillocks of salt, from fourteen to thirty inches in height. The streams were dry, but the surface of the clayey soil was covered, to the extent of a few hundred yards toward the plain, with a white crust of saline particles."

Mr. McConnell, of the Geological Survey, in the summer of 1887, ascended Salt river as far as the brine springs and gives a full account in his report² for that year. He says in part:—

Near the springs the river forks, and while one branch turns off to the south, the other pursues a winding way through the salt plains. These plains are four or five miles in width, and are bounded to the west and north by swelling ridges, covered with spruce and aspens, the leaves of which at this date, 26th August, were already turning yellow. The plains are well grassed, and in former days were the favorite feeding grounds of the buffalo. . . . The springs have been visited and described by both Back and Richardson. They are situated near the base of the ridge mentioned above, are three or four in number, and are surrounded for some hundreds of yards by a salt-sprinkled and desolate looking clay flat, through which numerous briny streamlets make their way to the river. The springs are enclosed by small evaporating basins, the largest of which is about fifteen feet in diameter, and is crusted with a remarkably pure deposit of sodic chloride. The salt obtained here is of excellent quality, and has been used in the Mackenzie river district for many years.

This district was again visited in 1902 when Mr. Chas. Camsell, of the Geol. Survey, made a trip up the Salt river about 20 miles above the salt springs. He states³:—

The brine springs which occur near the forks of the river and from which the Hudson's Bay Co. gets its supply of salt, were located and an observation for latitude taken to determine their position more accurately. Other brine springs were also discovered about six miles south-east of the forks. A much larger accumulation of salt occurs here, but on account of their being some distance from navigable waters, the salt from these springs has never been utilized. All these springs are situated along the base of the escarpment and at the time of our visit were nearly dry. They generally rise among from an accumulation of granite boulders and flow thence into shallow basins, where the water is evaporated, leaving a deposit of coarse salt. The stumps of trees, the boulders and the ground in the neighbourhood of the springs are all incrustated with the salt.

¹Narrative of the Arctic Land Expedition, p. 80.

²Geol. Surv. Can., Vol. IV, pp. 62-63D.

³Geol. Surv. Can., Vol. XV., p. 153A.

It is from these springs that the supply of salt for the Mackenzie Basin has been obtained by the Hudson Bay Co. for many years.

It is a pity that among all the numerous descriptions of these springs there does not appear to have been any analyses made of the brines. Nothing can be said as to the future possibilities of this area as a producing district. At the present time transportation facilities are too difficult and expensive to allow of any salt being brought down to Edmonton, and except for the small quantity employed for use locally by the Hudson Bay Co. there has been no salt produced from this area.

TAR ISLAND, PEACE RIVER.

Mr. McConnell speaks of the occurrence of a saline spring at this place as follows:—"A saline spring, emitting natural gas and carrying up small quantities of tar, occurs on the boulder bench at the upper end of Tar island, about thirty miles below the Smoky River forks. . . . A second spring is noted to occur on an island opposite the mouth of White Mud river, but this was not seen."

RED EARTH CREEK.

Mr. McConnell noted¹ and examined a saline spring about 2 miles above the mouth of Red Earth (Clay?) creek. Here a copious saline spring bubbles up about 100 feet from the west bank of the river and feeds a considerable stream. Large quantities of hydrogen gas escape at the same place and taint the air for half a mile around. An analysis of the water is here given²:—

Analysis.

Hypothetical Combustion.

Grammes per litre.

Potassium.....	0.036	Chloride of potassium...	0.069
Sodium.....	4.783	" " sodium.....	12.165
Calcium.....	0.947	Sulphate of lime.....	3.220
Magnesium.....	0.122	" " magnesia....	0.618
Sulphuric acid (SO ₄)....	2.759		
Chlorine.....	7.394		

Specific Gravity at 15.5° C., 1.012.

¹Geol. Surv. Can., Vol. V, Pt. 1, p. 49D.

²Geol. Survey of Canada, Vol. V, Pt. 1, p. 36D.

³Geol. Surv. Can., Vol. VI, p. 80R.

SALT OCCURRENCES ON LINE OF 5th MERIDIAN.

Mention is made by Mr. A. W. Ponton, D.L.S., of encountering saline creeks crossing the survey line of the 5th Meridian. He says:—¹

A long saline slough, sixty feet wide, occurs in section 25, township 106, and a river one hundred and twenty-five feet wide, in section 1, township 107, which shows a slight current; it is also saline. This river joins Birch river and is no doubt the Stinking creek shown on maps of the district. Both the salt water courses referred to have channels as regular as artificial canals, and their sources are no doubt salt springs situated west of the meridian.

Another saline creek is reported to cross the 5th meridian near the point where the Wabiskaw river crosses this meridian.

NAHANNI BUTTE-LIARD RIVER.

A salt spring is reported to occur in this district by Sir J. Richardson. He did not ascend the Liard river himself, but was informed by Mr. McPherson that 75 miles from its mouth there is a high hill, called "Nohhanni Butte," on the summit of which is a salt spring. Mr. McConneu, in August, 1887, visited this locality, but was unable to locate the spring mentioned. He states that:²—

A salt spring, with a basin fifteen feet in diameter, is reported by Sir J. Richardson on the authority of Mr. McPherson, as existing on the top of the mountain, but this I did not succeed in finding. A neighbouring mountain, however, showed a white patch on its steep side which is plainly marked due to the deposits of a mineral spring of some kind, and may be the one referred to.

GREAT BEAR RIVER (MACKENZIE BASIN), NORTHWEST TERRITORY.

Near the mouth of the Great Bear river, a river flowing from the lake of the same name and emptying into the Mackenzie river at Ft. Norman, there is reported³ to be a small stream flowing in from the southward near the sources of which the Indians procure an excellent common salt, which is deposited from the springs by natural evaporation.

Numerous other springs have been noted from time to time in the country tributary to the Mackenzie and among these there may be noted the following:—

Firebag river.—On north bank 14 miles from mouth and also on south bank 11 miles from mouth.

¹Annual Rept., Topog. Surv. Br., Dept. Interior, 1908-1909. Appendix No. 36, p. 171.

²Geol. Surv. Can., Vol. IV, p. 57D.

³Geol. Survey of Can., Vol. II, p. 20R.

Christina river.—14 miles from mouth on southeast bank.

In the prairie country lying between Manitoba and British Columbia and the Winnipeg-Edmonton line of the Canadian Pacific railway and the International Boundary, numerous alkali or saline lakes are known to occur; and although it is not probable that any of these are valuable for the manufacture of salt, their occurrence is noteworthy on account of the possibility of their containing some of the rarer and more valuable potash salts. It is sufficient therefore, in this report, to mention a couple of localities.

CYPRESS HILLS, SASK.

the plain lying to the north of Cypress hills Mr. R. G. McConnell made note of the occurrence of numerous lakes which are more or less saline. These lakes, he says,¹

vary through every degree of salinity, from those covered with a thick crust of crystallized salts down to others in which the water is perfectly fresh, and the two extremes are not infrequently met with side by side. At one point, near the west end of Bitter lake, one of the most saline lakes of the district, a spring of fresh water was found bubbling up on the beach, and the same thing was noticed at several other places. As a rule, however, saline lakes occur more frequently in the low-lying areas, and fresh water lakes on the higher ground.

About 18 miles to the east of Wetaskiwin, a town on the Calgary to Edmonton branch of the Canadian Pacific railway, the writer visited a lake called Bittern lake, which was decidedly saline to the taste. There are several other lakes in this district which are also saline.

¹Geol. Surv. Can. Vol. 1, 1885, Pt. C, p. 15C.

CHAPTER VII.

SALT IN BRITISH COLUMBIA.

Within the last few years, the occurrence of salt in British Columbia was in the form of a number of saline or mineral springs, the waters of which are more or less saline.

In August, 1911, however, reports came in of the discovery of a strong saline spring 45 miles from Prince Rupert, situated on the banks of the Skeena river, at Kwinitsa, on the line of the Grand Trunk Pacific railway. That year, the location of the spring was staked and recorded by one of the cooks in the construction camps. Experiments were carried on in a crude way and it was found that the brine was strong enough to collect considerable quantities of a good quality of salt, by evaporation.

Early in 1913, a syndicate of western men started drilling operations in an endeavour to locate rock salt at this point, and in April of the same year, their efforts were rewarded—according to reports—by encountering salt in five different holes. The following account of this discovery is taken from the Vancouver Daily Province—April 15, 1913:—

EXTENSIVE BED OF ROCK SALT.

Found on the Skeena River near Prince Rupert.

Prince Rupert, April 15.—An extensive bed of rock salt has been discovered at Kwinitsa (Mile 45) on the Skeena River. For some time it has been known that salt existed at this point, and tests were made by F. H. Mobley, Mr. D. Whiteford and others. A few days ago a solid salt bed was struck by the drilling party.

So far five holes have been drilled at considerable distances apart, some more than a mile from others and all have struck salt at depths varying from 50 to 250 feet.

At the property Messrs. Moberly and Whiteford have an up-to-date drilling outfit and have erected a small testing plant, consisting of three evaporating pans.

Up to the present about eight tons of salt have been secured from the deposits. The most thorough tests show that it is absolutely pure and of the best quality.

The principal salt wells of Canada are located in Western Ontario. On account of the long haul most of the salt used in British Columbia is imported from California. The presence of valuable salt beds in the immediate vicinity of this city is therefore of great importance, especially in connection with the fishing industry on the coast."

During 1913, fifteen tons of salt were produced from this deposit, which were either sold or given away.

A company entitled the British Columbia Salt Works, Ltd., Prince Rupert, B. C., has lately been organized, and it is hoped to have a plant installed during the summer (1914).

There is, according to reports, a local market of 60 tons of salt per day for use in the fisheries' industry of the British Columbia coast.

Of the saline springs occurring elsewhere in the Province, none are of any great importance. The most strongly saline are those at Nanaimo, and Admiralty or Salt Springs island; but the flow of these is not so copious, or the strength of the brine sufficient, to warrant a belief in their economic importance. Brief descriptions of several of these localities are here given.

Nanaimo-Vancouver Island and Admiralty Island, B.C.

"*Nanaimo*.—Salt Spring. Issues from the Cretaceous coal-bearing strata near the Douglas seam, and according to Mr. Richardson has a flow of two to three gallons a minute. The Hudson Bay Company at one time attempted the manufacture of salt here, but it was soon abandoned. The brine has been analyzed by Mr. Hoffman who found it to contain 52.154 parts of saline matter in 1,000. Of this thirty-nine parts were common salt and the remainder largely calcium chloride. According to an analysis quoted by Pemberton, it contained 49 parts of salt to 1,000 in 1854. (Report 1872-73, p. 82. Facts and Figures relating to Vancouver Island, etc., p. 159)."

"*Admiralty Island*.—Salt Springs. According to analysis quoted by Pemberton in the place above cited, the spring contains 65 parts of saline matter to 1,000, but with more impurities than the last."¹

CHILCOTIN VALLEY, B. C.

Small saline lakes were noticed in the locality by G. M. Dawson, in 1875.

MAIDEN CREEK, BONAPARTE VALLEY, N.W. OF ASHCROFT, B.C.

Dr. G. M. Dawson, in his report on British Columbia, makes reference to several localities in which saline springs occur. Of the principal district, he says²:—

Many small saline springs occur in this district which are due merely to the accumulation of salts in the superficial deposits of the drier valleys, and a number of the small pools and lakelets without outlets are charged with similar salts, but the only known mineral spring of any possible importance is situated on Maiden creek, four or five miles west of Mundorf's. This is described by Mr. A. Bowman as being charged with carbonic acid.

The analysis of water from this spring shows the presence of a small quantity of sodium chloride.

¹Geol. Surv. Can., Vol. III, Pt. 2, p. 162R.

²Geol. Surv. Canada, Vol. VII, p. 347B.

CHAPTER VIII.

STATISTICS OF CANADIAN SALT PRODUCTION.

The production of salt in Canada has, for a number of years, been obtained wholly from salt fields in southwestern Ontario, although there was at one time a very small production in both New Brunswick and Manitoba. The salt produced in Canada, however, is only 41 per cent of the total home consumption; the balance being imported, principally for the use of the coast provinces, and the fisheries.

A comparison of the Canadian production with that in foreign countries is given in Table XI taken from "The Mineral Industry during 1912," Vol. XXI, p. 768.

The following tables are compiled from the Annual Reports on the Mineral Production of Canada, prepared under the direction of Mr. John McLeish, Chief of the Division of Mineral Resources and Statistics, and were published by the Mines Branch during the last few years. The ton stated is the short ton of 2,000 pounds.

The annual production during the last ten years has shown, each year, a small but steady increase. Few changes have taken place in either the number of companies producing, or the localities from which the salt is being obtained; and unless new and more favourably situated deposits are opened up in either the Maritime Provinces or the western part of Canada, it is hardly likely that any great advancement in the annual production will occur in the near future. The larger companies in the Ontario district are all well equipped, and are capable, if required, of filling the annual demand for many years to come. The industries allied to the salt industry, such as those using salt brine for the manufacture of caustic soda and bleaching powder, may, in time, help to swell the total production, but as yet these are in their infancy in Canada.

The total sales of salt in 1913, were 100,791 tons, valued at \$491,280, exclusive of packages, as compared with sales of

TABLE XI.
Production of Salt in Foreign Countries
(In metric tons)

	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911
U. States.....	2,409,174	2,408,646	2,797,461	3,297,285	3,578,061	3,773,781	3,742,726	3,823,068	3,849,035	3,159,800
U. Kingdom...	1,924,273	1,917,184	1,921,899	1,920,149	1,996,593	2,016,510	1,873,555	1,851,999	2,083,543	2,116,115
Germany.....	1,583,458	1,693,935	1,701,654	1,177,557	1,870,212	1,950,689	1,997,635	2,018,607	2,093,184	2,032,483
Russia.....	1,847,019	1,658,938	1,908,275	1,844,678	1,730,934	1,873,171	1,879,717	2,255,233	2,047,980	(c)
India (d).....	1,056,899	908,911	1,188,900	1,212,600	1,176,324	1,120,453	1,390,153	1,275,688	1,720,194	1,495,687
France.....	863,927	967,531	1,153,754	1,130,000	1,335,410	1,226,000	1,099,856	1,113,000	1,051,427	1,339,000
Spain.....	426,434	427,394	543,674	493,451	541,978	605,895	822,677	800,703	678,057	654,767
Japan.....	620,820	657,489	701,965	483,506	484,000	636,168	659,202	696,049	696,474	567,715
Italy.....	458,497	488,506	464,326	437,699	496,872	505,000	513,070	464,469	503,237	521,453
Hungary.....	174,882	183,327	187,620	195,410	201,369	395,000	(c)	231,182	230,315	239,006
Austria.....	310,807	359,014	369,877	343,375	378,912	398,033	388,133	359,801	345,629	342,732
Canada.....	57,203	56,671	62,411	41,170	69,291	7,358	76,219	76,286	76,310	83,105
Greece.....	25,200	26,000	27,000	25,201	25,167	26,966	23,988	29,448	25,978	59,940
Algeria.....	27,263	26,329	18,563	27,000	22,615	20,400	25,215	17,817	21,470	20,400

(c) Statistics not yet published.

(d) Does not include the untaxed output of certain native states.

95,053 tons, valued at \$459,582, in 1912, showing a continued increase in production.

The average number of men employed during the year was reported as 251, and the amount paid in wages, \$178,386. The value of the packages used during the year was \$262,479, and stock of salt in manufacturers' hands at the close of the year was reported as 4,066 tons.

Detailed statistics of the production during the past six years showing the total sales of salt; the value of the sales, exclusive of packages; the value of the packages used; stock in manufacturers' hands at the end of each year; number of men employed, and wages paid, are given in Table XII; while the total annual production since 1886 is given in Table XIII.

TABLE XII.

Detailed Statistics of Production 1908-1913

	1908.	1909.	1910.	1911.	1912.	1913.
Sales of salt.....Tons	79,975	84,037	84,092	91,582	95,053	100,791
Value of salt (exclusive of packages).....\$	378,789	415,219	409,624	443,004	459,582	491,280
Value of packages.....\$	168,019	175,612	173,446	198,789	224,696	262,479
Stock in manufacturers' hands at end of year.....Tons.	5,631	2,671	2,474	1,422	3,256	4,066
Men employed.....No.	207	185	208	225	231	251
Wages paid.....\$	95,575	96,116	112,909	123,040	155,648	178,386

TABLE XIII.

Annual Production, 1886-1913

Calendar Year.	Tons.	Value.	Calendar Year.	Tons.	Value.
		\$			\$
1886.....	62,359	227,195	1900.....	62,055	279,458
1887.....	60,173	166,394	1901.....	59,428	262,328
1888.....	59,070	185,460	1902.....	64,456	292,581
1889.....	32,832	129,547	1903.....	62,452	297,517
1890.....	43,754	198,857	1904.....	69,477	321,778
1891.....	45,021	161,179	1905.....	67,340	320,858
1892.....	45,486	162,041	1906.....	76,720	329,130
1893.....	62,324	195,926	1907.....	72,697	342,315
1894.....	57,199	170,687	1908.....	79,975	378,798
1895.....	52,376	160,455	1909.....	84,037	415,219
1896.....	43,960	169,693	1910.....	84,092	409,624
1897.....	51,348	225,730	1911.....	91,582	443,004
1898.....	57,142	248,639	1912.....	95,053	459,582
1899.....	59,339	254,390	1913.....	100,791	491,280

Until the last three years, the salt industry as carried on in western Ontario, consisted essentially in the production of table, dairy, and coarse salt, also a small quantity of land salt. In 1911, however, the Canadian Salt Company, at their Sandwich branch, installed a plant for the manufacture of caustic soda and bleaching powder. This plant commenced operations during the last week of 1911, and has operated ever since. In order to show the great opportunity for plants of this kind in Canada, the imports of some of the soda products during the calendar years 1911, 1912, and 1913, are shown in Table XIV.

TABLE XIV.
Imports of Soda Products into Canada.

	1911.		1912.		1913.	
	Lbs. imported.	Value.	Lbs. imported.	Value.	Lbs. imported.	Value.
		\$		\$		\$
Soda, ash or barilla.....	44,682,937	375,132	52,167,811	421,959	66,323,869	492,115
Soda bichromate	327,307	19,193	584,424	33,744	674,456	33,767
Caustic soda in packages, 25 lbs. or more..	13,708,922	253,612	14,544,545	273,579	15,896,076	286,432
Sal soda.....	10,202,422	64,107	9,996,562	64,020	8,688,607	53,649
Sulphate of soda	13,782,241	88,761	19,243,823	97,768	25,902,190	133,030
		800,805		896,070		998,993

In order to encourage the manufacture of these products in Canada, the present government has placed a duty on imports as follows:—

	British Preferential Tariff.	Interme- diate Tariff.	General Tariff.
208a. Chloride of lime, and hypochlorite of lime:—			
(1) When in packages of not less than twenty-five pounds weight each, . . . per one hundred pounds	10 cents	15 cents	15 cents
(2) When in packages of less than twenty-five pounds weight each, ...	17½ p.c.	25 p.c.	25 p. c.

209a. Caustic Soda:—

(1) When in packages of not less than twenty-five pounds weight each, . . .	1-5 cents	3-10 cents	3-10 cents
(2) When in packages of less than twenty-five pounds weight each	17½ p.c.	25 p.c.	25 p.c.

This duty came into effect on April 7, 1914. It is hoped that by imposing this duty, the Canadian manufacturers may be enabled to gain the whole of the Canadian trade.

EXPORTS AND IMPORTS.

Comparatively small quantities of salt are now exported from Canada, the exports in 1913 being 460,900 pounds, valued at \$3,047.

The imports of salt, on the other hand, are quite considerable, and in total value greatly exceed the domestic production. For the calendar year, 1913, the imports of salt subject to duty, included: salt in bulk dutiable at 5 cents per 100 pounds, 22,787 tons, valued at \$73,115; and salt in bags, barrels, or other packages, dutiable at 7½ cents per 100 pounds, 8,720 tons, valued at \$74,660. Salt imported from the United Kingdom or any British possession, or imported for the use of the sea or gulf fisheries, duty free, was imported to the extent of 112,939 tons, valued at \$417,508, giving total imports of 144,446 tons, valued at \$565,283.

Tables XV, XVI, and XVII, following, give the statistics of exports and imports of salt into Canada since 1880.

TABLE XV.
Exports of Salt.

Calendar Year.	Bushels.	Value.	Calendar Year.	Bushels.	Value.
		\$			\$
1880.....	467,641	46,211	1898.....	5,202	1,252
1881.....	343,208	44,627	1899.....	11,205	2,773
1882.....	181,758	18,350	1900.....	37,653	8,997
1883.....	199,733	19,492	1901.....	39,224	6,510
1884.....	167,029	15,291	1902.....	9,331	3,798
1885.....	246,794	18,756			
1886.....	224,943	16,886		Lbs.	
1887.....	154,045	11,526	1903.....	1,915,648	5,927
1888.....	15,251	3,987	1904.....	1,006,036	4,186
1889.....	8,557	2,390	1905.....	1,447,728	6,112
1890.....	6,605	1,166	1906.....	618,707	3,437
1891.....	5,290	1,277	1907.....	2,222,542	7,709
1892.....	2,000	504	1908.....	529,229	3,840
1893.....	4,940	1,267	1909.....	276,765	2,488
1894.....	4,639	1,120	1910.....	275,200	2,618
1895.....	4,865	959	1911.....	454,600	5,055
1896.....	3,842	899	1912.....	289,150	3,723
1897.....	5,383	1,193	1913.....	460,900	3,047

TABLE XVI.
Imports:—Salt Paying Duty.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
		\$			\$
1880.....	726,640	3,916	1897.....	11,911,766	33,470
1881.....	2,588,465	6,355	1898.....	11,068,785	32,792
1882.....	3,679,415	12,318	1899.....	11,781,453	32,839
1883.....	12,136,968	36,223	1900.....	11,028,337	30,180
1884.....	12,090,950	38,949	1901.....	11,625,688	34,087
1885.....	10,077,761	31,726	1902.....	13,892,849	39,605
1886.....	12,266,021	39,181	1903.....	14,554,693	41,785
1887.....	10,413,258	35,670	1904.....	29,779,183	73,826
1888.....	10,509,799	32,136	1905.....	18,473,868	58,056
1889.....	11,190,088	38,968	1906.....	21,366,064	59,805
1890.....	15,135,109	57,549	1907 (9 mos.).....	21,834,435	58,553
1891.....	15,140,827	59,311	1908.....	31,019,400	79,341
1892.....	18,648,191	65,963	1909.....	31,653,900	83,660
1893.....	21,377,339	79,838	1910.....	35,230,000	83,043
1894.....	15,867,825	53,336	1911.....	39,251,300	94,461
1895.....	8,498,404	29,881	1912.....	50,038,300	116,097
1896.....	7,665,257	24,550	1913.....	60,874,900	137,340

	1912.		1913.	
	Pounds.	Value.	Pounds.	Value.
Salt, fine, in bulk, N.E.S. (a).....	35,436,700	\$55,089	42,990,700	\$73,848
Salt, N.E.S., in bags, barrels or other packages (b).....	14,601,600	61,008	17,884,200	73,492
Total.....	50,038,300	116,097	60,874,900	137,340

(a) Duty 5c per 100 lbs. (b) Duty 7½c. per 100 lbs.

TABLE XVII.

Imports:—Salt Not Paying Duty.

Fiscal Year.	Pounds.	Value.	Fiscal Year.	Pounds.	Value.
		\$			\$
1880.....	212,714,747	400,167	1897.....	215,844,484	312,117
1881.....	231,640,610	488,278	1898.....	202,634,927	293,410
1882.....	166,183,962	311,489	1899.....	183,046,365	267,520
1883.....	246,747,113	386,144	1900.....	193,554,550	295,253
1884.....	225,390,121	321,243	1901.....	216,271,603	339,887
1885.....	171,571,209	255,719	1902.....	238,648,737	385,629
1886.....	180,205,949	255,359	1903.....	232,708,675	361,185
1887.....	203,042,332	285,455	1904.....	198,634,047	338,082
1888.....	184,166,986	220,975	1905.....	196,907,500	340,954
1889.....	180,847,800	253,009	1906.....	203,080,000	352,214
1890.....	158,490,075	252,291	1907 (9 mos.).....	139,459,900	240,841
1891.....	195,491,410	321,239	1908.....	200,944,800	350,878
1892.....	201,831,217	314,995	1909.....	232,237,700	376,961
1893.....	191,595,530	281,462	1910.....	232,559,900	382,210
1894.....	196,668,730	328,300	1911.....	205,784,700	330,251
1895.....	201,691,248	332,711	1912.....	212,552,200	332,554
1896.....	205,005,100	338,888	1913*.....	218,852,300	362,755

*Salt imported from the United Kingdom, or any British possession, or imported for the use of the sea or gulf fisheries.

TABLE XVIII.

Consumption of Salt in Canada in 1912 and 1913.

	1912.		1913.	
	Pounds.	Value.	Pounds.	Value.
		\$		\$
Canadian salt production.....	190,106,000	459,582	201,582,000	491,280
Less exports.....	289,150	3,723	460,900	3,047
	189,816,850	455,859	201,121,100	488,133
Imports of salt paying duty....	60,134,500	133,869	63,015,000	147,775
Imports of salt free of duty....	219,278,900	352,081	225,877,200	417,508
	469,230,250	941,809	490,013,300	1,053,416

The following is a list of operators:—

Operator.	Address.
The Canadian Salt Co., Ltd.	Windsor, Ont.
The Canadian Salt Co., (Sandwich branch) ..	Windsor, Ont.
The Western Salt Co., Ltd.	Mooretown, Ont.
Dominion Salt Co., Ltd.	Sarnia, Ont.
Carter and Kiddermaster.	Sarnia, Ont.
The Elarton Salt Works, Co., Ltd.	Hyde Park Corner, Ont.
Parkhill Salt Co.	Parkhill, Ont.
Exeter Salt Works Co.	Exeter, Ont.
Western Canada Flour Mills Co., Ltd.	Goderich, Ont.
North American Chemical Co. (J. Ransford) ..	Goderich, Ont.
Stapleton Salt Works (Jno. Ransford).	Clinton, Ont.
Grey, Young and Sparling Co., of Ont., Ltd.	Wingham, Ont.
Ontario People's Salt and Soda Co., Ltd.	Kincardine, Ont.

For a full description of these companies and their plants, see Chapter IV.

CHAPTER IX.

Introduction.

TECHNOLOGY OF SALT MANUFACTURE.

The recovery of salt from nature has been practised from the earliest times. The first methods were very crude, and consisted either of excavating it in its native state—from the numerous deposits of rock salt which have been known for many ages—or else evaporating the brine of the salt springs or sea water by means of natural or artificial heat. The necessity of salt to both man and beast is so vital that the country which contains a supply within its borders has a great advantage over its neighbours. In the early writings of the Romans it is stated that many wars were fought by the early European tribes for the possession of salt springs located near the border lines of the respective countries.

The earliest processes consisted either of allowing sea water to evaporate in shallow basins near the sea shore, by means of the heat of the sun; or else evaporating the brine, obtained from springs, in small earthenware pots; or, by burning brush, throwing the brine over it, and collecting the salt deposited thereon. It was not until the end of the eighteenth and beginning of the nineteenth centuries that the methods used in the recovery of salt from brines showed much improvement over that of the ancients. The industry then began to improve, and more economical means for the production were looked for. The common method of solar evaporation was greatly improved, and put on a more economical basis. The kettle, and pan processes, were gradually evolved; and in late years, with the advent of steam evaporation in the "grainer" process, and the vacuum process, the salt industry has advanced by leaps and bounds. The following diagram (Fig. 20), shows at a glance, the principal methods employed at the present time for the production of commercial salt. These different methods will now be described under their different headings.

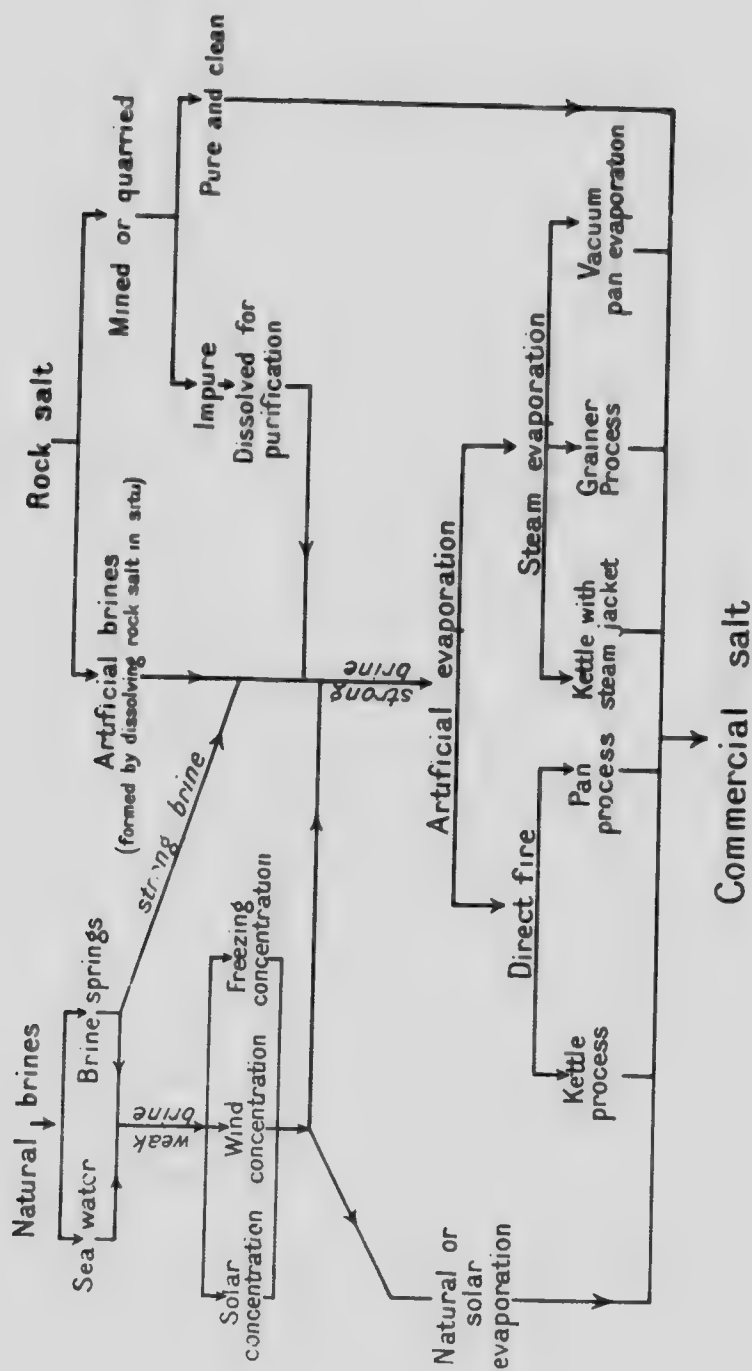


Fig. 20. Flow sheet showing methods of salt recovery.

RECOVERY OF SALT.

Commercial salt is obtained from two sources in nature: (1) natural brines, (2) rock salt.

Natural Brines.

Natural brines may be divided into two classes: (1) sea water, (2) brine springs.

SEA WATER.

Sea water has been, from the earliest times, one of the commonest sources of salt for domestic use. Of late years, however, owing partly to the discovery of beds of rock salt and saturated brine springs, and to improved methods of artificial evaporation, the recovery of salt from sea water has gradually decreased, and, now manufacture is practically limited to the seaboard and salt lakes, where the climate is dry and warm for long seasons in the year.

In the recovery of salt from sea water, solar evaporation is almost exclusively relied upon.

Inland lakes and seas—such as the Great Salt lake, Utah, and the Dead sea, Palestine, also furnish a source for the production of domestic salt by means of solar evaporation.

BRINE SPRINGS.

Brine springs in many countries have been—until the last 50 years—one of the chief sources from which salt was obtained. With the discovery of rock salt beds, the springs—unless of great strength—have been gradually abandoned on account of the greater cheapness of the direct mining of the salt, or preparing salt from the saturated brines. In Canada, at the present time, there is no salt being manufactured from the natural brines.

Rock Salt.

Rock salt is found in many countries in beds of such extent as to permit of it being mined or quarried; or else recovered by dissolving the beds with water and pumping the resultant brine to the surface, to be evaporated.

Where the salt beds are sufficiently near the surface to enable the salt to be recovered directly, the common practice is to either quarry it or mine it by the pillar and chamber method. In the former case it is taken from an open quarry, possibly with very little stripping. Mining is generally carried on from a shaft sunk to tap the deposits. Galleries are run, and chambers mined out on each side of the gallery, leaving pillars at regular intervals.

The salt from both quarry and mine is generally crushed in cast iron rolls, after which it is screened. The coarse lumps are sold as lump salt while the material passing through the screens is fed into buhr mills. The ground salt from these buhr mills is passed through pneumatic separators, which take out the dust, and separate the market salt into the different grades. When the salt is too impure to handle in this manner, it is dissolved in large tanks, and the saturated brine is evaporated by one of the several methods hereinafter described.

ARTIFICIAL BRINES.

Where the beds of rock salt are at too great a depth to be worked economically by mining methods, the common practice is to recover the salt by putting a drill hole down to the beds and dissolving the salt by means of water, afterwards pumping the saturated brine to the surface and evaporating it.

The drilling of the wells is accomplished by the ordinary churn drill, common to oil drilling practice: the diameter of the holes at the collar being between 8" and 10". It is customary to carry the hole several feet through the salt bed, and to blast or torpedo the bottom in order to form a collecting chamber for the brine, when formed. The hole is then cased, in order to ensure that the brine will not escape through some of the overlying porous strata.

There are several methods employed in the pumping of the brine.

In the northern part of the Ontario salt field, where underground waters form the solvent for the salt, the most common practice is to pump the brine through the casing of the hole, by means of a plunger pump—after the Cornish pump pattern, with walking beam. In the southern part of this field, where water has to be forced down the hole, the common method adopted is to case the hole down to the top of the salt strata, and then to put down an inner piping, almost to the bottom of the hole. The case pipe has a diameter of from 6" to 8", and the inner pipe from 3" to 4". The joint between case pipe and the hole is made tight by a heavy rubber washer. Fresh pure water is then forced down the space between the outer casing and the inner pipe under sufficient pressure to cause the brine to flow up the inner tube. The brine pipe reaching to the bottom of the cavity ensures a saturated solution ascending to the surface.

A third method, sometimes adopted, is to pump the brine by means of compressed air. In this method the double tubing is also required, air being forced down the inner tube, and allowed to rise through the outer tube, carrying with it the brine.

The brine coming from the wells is piped to settling tanks, where it is allowed to stand for a certain length of time, in order to allow any sediment or mechanically suspended matter to settle. In these tanks the brine is sometimes treated with lime, to precipitate any gypsum present; and in some plants is partially heated by means of exhaust steam, so that time will be gained when the brine is fed into the evaporators.

CONCENTRATION OF WEAK BRINES.

In the case where the natural brines are low in sodium chloride content, they can be concentrated into strong or saturated brines, by one of the three following methods:—

- (a) Solar Concentration.
- (b) Wind Concentration or Graduation Process.
- (c) Freezing Concentration or Congelation Method.

(a) Solar Concentration.

In this method the excess water is removed by the natural heat furnished by the sun, and the weak brine brought to the point of saturation, and then further evaporated either by natural or artificial heat. The complete method employed in the production of salt by this means is fully described later in this chapter, under Solar Evaporation.

(b) Wind Concentration or Graduation Method.

A method which has, to some extent, found favour in the concentration of the weak brines which occur in many places in France and Germany, consists in allowing the brine to trickle slowly in a continuous stream over walls of thorns or brushwood exposed to the sun and wind. This process is called the method of graduation, and is carried on in what are called "graduation houses." These houses consist of large wooden trestles covered in on the top, to exclude the rain, but left open at the ends to allow of free circulation of air through the building. The plant consists of a long shallow cistern, built of wooden planks, above which is arranged a wall of thorns and brushwood built up between the two wooden walls, to the height of 30 to 50 feet. Above this wall is a reservoir for the weak brine, or else a long trough furnished with stopcocks. The weak brine is pumped into this reservoir or trough, and allowed to flow either over the surface or through the brushwood wall, and is collected in the vat or cistern situated on the floor of the building. The building is built lengthwise in the direction of the prevailing wind of the region, with its ends left open. The brine thus trickling through the brushwood, affords a tremendous evaporating surface to the wind circulating through the building, so that a considerable concentration is effected. The brine must be the more frequently pumped up and allowed to flow through the brush wall according to the weakness of the original brine. This is accomplished by making the brine flow down over the thorns in different compartments of the building called the 1st, 2nd, and 3rd graduation. The arrangement is so made that the brine resulting from the

3rd, or last graduation, is of sufficient strength to be economically evaporated by one of the methods of artificial evaporation.

The success of this process is naturally dependent on the state of the atmosphere, and its use is consequently limited to certain districts, and to the favourable time of the year.

(c) Freezing Concentration or Congelation Method.

The theory upon which this process is based, takes into consideration the fact that, when a solution of salt and water solidifies, or partially solidifies, it does so in a definite manner, depending upon the proportion of NaCl in the water. For example¹ if a solution of common salt in water, with a definite composition of 23.6 per cent of NaCl in the mixture, which freezes at 22° C., is cooled to the proper temperature, then the entire mass of salt and water solidifies. If less than that proportion of salt is present, ice will crystallize first and will continue to separate out until the proportion above stated is reached.

"If on the other hand, salt is in excess of 23.6 per cent, its Hydrate, $\text{NaCl} \cdot 2\text{H}_2\text{O}$ will first appear and continue to be deposited until the point of equilibrium has been attained."

The whole mass will then solidify as above stated.

"This minimum temperature, with its definite, corresponding concentration of salt and water, is known as the eutectic point and at that point the solution and the solid will have the same composition."

Above this eutectic point, one may have either salt or water crystallizing out, according as to which substance is present in the solution in excess of the eutectic ratio, i.e., 23.6 NaCl to 76.4 H_2O . Thus in the freezing of sea water, or a weak brine, the separation of nearly pure ice is seen; because the water is largely in excess of the eutectic proportions, and the remaining solution is correspondingly stronger in NaCl.

In the northern part of Europe this method has attained some degree of success. The weak brine, contained in large reservoirs, is submitted to successive partial congelations and the ice is removed as fast as it forms. The resultant mother liquor containing a higher percentage of sodium chloride is again submitted to the freezing process until finally a saturated

¹See Data of Geochemistry, page 287.

solution is obtained which can then be treated by one of the methods of artificial evaporation, and commercial salt prepared. In districts where the atmosphere is dry, and a constant temperature below freezing is maintained for any length of time, this method should prove a cheap means of producing a saturated brine suitable for the preparation of salt on an economically commercial scale.

EVAPORATION METHODS.

A great number of different methods have been used at various times for the recovery of salt from brines, each one being adapted to suit local conditions. These different processes can be conveniently divided into two groups, according to the heat employed and the mode of application: (1) Natural Evaporation (2) Artificial Heat Evaporation.

Natural or Solar Evaporation

The recovery of salt from sea water and weak brines has, in nearly all cases, been made by the solar method: employing the agency of the heat of the sun and wind. Owing to the writer not being able to visit any of these plants in operation, the following description, taken from Mr. G. P. Merrill's book on Non-metallic Minerals, is given:—

"In the preparation of salt from sea water, solar exaporation alone is relied upon nearly altogether. This method, like the next to be mentioned, depends for its efficiency upon the fact already noted—that sea water holds in solution besides salt various other ingredients, which, owing to their varying degrees of solubility, are deposited at different stages of concentration. In Barnstable County, Massachusetts, it was as follows: A series of wooden vats or tanks, with nearly vertical sides and about a foot in depth, is made from planks. These are set upon posts at different levels above the ground, and so arranged that the brine can be drawn from one to the other by means of pipes. Into the first and highest of these tanks known as the "long water room," the water is pumped directly from the bay or artificial pond by means of windmills, and there allowed to stand for a period of about ten days, or until all the sediment it may carry is deposited. Thence it is run through pipes to the second tank, or "short water room," where it remains exposed to evaporation for two or three days longer, when it is drawn off into the third vat, or "pickle room," where it stands until concentration has gone so far that the lime is deposited and a thin pellicle of salt begins to form on the surface. It is then run into the fourth and last vat, where the final evaporation takes place and the salt itself crystallizes out. Care must be exercised,

however, lest the evaporation proceed too far, in which case sulphate of soda (Glauber's salt) and other injurious substances will also be deposited, and the quality of the sodium chloride thereby greatly deteriorated.

As to the capabilities of works constructed as above, it may be said that during a dry season vats covering an area of 3000 square feet would evaporate about 32,500 gallons of water, thus producing some 100 bushels of salt and 400 pounds of Glauber's salt. The moist climate of the Atlantic States, however, necessitates the roofing of the vats in such a manner that they can be protected or exposed as desired, thereby greatly increasing the cost of the plant. Sundry parts of the Pacific coast, on the other hand, owing to their almost entire freedom from rains during a large part of the year, are peculiarly adapted for the manufacture by solar evaporation. Hence, while the works on the Atlantic coast have nearly all been discontinued, there has been a corresponding growth in the west, and particularly in the region about San Francisco Bay.

The methods of procedure in the California works do not differ materially from that already given, excepting that no roofs are required over the vats, which are therefore made much larger. One of the principal establishments in Alameda County may be described as follows: The works are situated on a low marsh, naturally covered by high tides. This has been divided, by means of piles driven into the mud and by earth embankments, into a series of seven vats or reservoirs, all but the last of which are upon the natural surface of the ground—that is, without wooden or other artificial bottoms. The entire area inclosed in the seven vats is about 600 acres, necessitating some 15 miles of levees. The season of manufacture lasts from May to October. At the beginning of the spring tides, which rise some 12 to 15 inches above the marsh level, the fifteen gates of reservoir No. 1, comprising some 300 acres, are opened and the waters of the bay allowed to flow in. In this great artificial salt lake the water is allowed to stand until all the mud and filth have become precipitated, which usually requires some two weeks. Then, by means of pumps driven by windmills, the water is driven from reservoir to reservoir as concentration continues, till finally the salt crystallizes out in No. 7, and the bitter is pumped back into the bay. The annual product of the works above described is about 2,000 tons.

A somewhat similar process is pursued in the manufacture of salt from inland lakes in the Great Salt Lake, Utah. The following account of the method here employed is by Dr. J. E. Talmage:—

The Inland Salt Company's gardens are situated near Garfield Beach, the most popular pleasure resort on the lake. In the method employed the water is pumped from the lake into ponds prepared for its reception and situated above the level of the lake surface. The mother liquors flow off—are returned to the lake in fact—when the evaporation has reached the proper stage. From the establishment of the works until 1883 the lake was close to the ponds; but, owing to the unusually high rate of evaporation attending the dry seasons of the immediate past, the water has receded, so that at present it has to be conveyed over 7500 feet to the evaporating receptacles. This is effected by the aid of two centrifugal pumps, raising together 14,000 gallons of water per minute. The pumps throw the water to a height of 14 feet into a flume, through which it flows to the ponds. These are nine in number, and are arranged in series. In the first pond the mechanically suspended matters are left as sediment or scum, and the water passes into the second in a clear condition. The ponds cover upwards of a thousand acres

and the drain channels leading from them aggregate nine miles in length. The pumping continues through May, June and July. A fair idea of the rate of evaporation in the thirsty atmosphere of the Great Basin may be gained from contemplating the fact that to supply the volume of water disappearing from the ponds by evaporation requires the action of the pumps ten hours daily in June and July. This is equal to the carrying away of 8,400,000 gallons per day from the surface of the ponds.

The 'salt harvest' begins in August, soon after the cessation of pumping, and continues till all is gathered, frequently extending into the spring months of the succeeding year. An average season yields a layer of salt 7 inches deep, which amount would be deposited from 49 inches of lake water. The density at which salt begins to deposit, as observed at the ponds and confirmed by laboratory experiments, is 1.2121, and that of the escaping mother liquors is 1.2345. The yield of salt is at the rate of 150 tons per inch per acre. The crop is gathered on horse cars, which run on movable tracks into the ponds. At the works the operations are simple and effective. A link belt conveyor carries the coarse salt to the crusher; thence to the dryer, after which a sifting process is employed by which the salt is separated into table salt and dairy salt.¹

The solar evaporation method as carried on in the states of Michigan and New York is slightly different from those already described. Dr. F. E. Englehardt, in F. J. H. Merrill's report on the salt industry of New York, gives the following description of the method as employed at Syracuse, N. Y.²—

The manufacture of solar salt, or as it is often called, coarse salt, is carried on in shallow wooden vats which, in order to protect the contents against rain, are provided with movable wooden covers, running on wooden rollers. At the end of the season the wooden rollers are removed and the covers or roofs fastened securely on the vats.

There are three sets of these, or as they are more familiarly called rooms. The first are called "deep rooms," and serve for the reception of the brine as it comes from the wells or pumphouse. The brine when received in these rooms is usually perfectly clear, but soon it becomes turbid and of a yellowish red color. This change is due to the escape of carbonic acid gas with which the brine is highly charged when it comes from the wells and by which the trace of ferrous carbonate present is held in solution. The solvent escaping, the ferrous oxide takes up oxygen and separates from the brine as a hydrated ferric oxide in a very finely divided state, causing a yellowish turbidity which disappears gradually as the ferric oxide settles to the bottom of the vat, and leaves the brine clear again. The deep rooms are constructed higher above the ground than the following set, which are called "lime rooms,"—(this is a misnomer, since in the manufacture of solar salt lime is never used)—in order to enable the workmen to draw from them into the lime rooms as occasion requires. The evaporation of water from the brine which commences in the deep rooms, continues in the lime rooms till the brine reaches its point of saturation, which is recognized by the workmen when small cubic salt crystals make their appearance. While the brine is evaporating and becoming saturated a second change takes place in it, namely, a certain amount of sulphate of lime or gypsum separates from it in beautiful crystals on the sides and bottom of the room. This separation is especially marked when the brine is

¹Science, XIV, 1889, p. 445.

²Bull. New York State Museum, Vol. 3, No. 11, 1893, pp. 39-44.

near its point of saturation. The now fully saturated brine is called pickle and is drawn into the third or lowest set of rooms called the "salt rooms." Here another change takes place. Salt and a portion for the remaining sulphate of lime crystallizes out, the former in more or less perfectly developed crystals, the latter in fine slender crystals often twinned. As the evaporation of the water from the pickle progresses, the salt crystals first formed increase in size, new ones make their appearance and soon the entire bottom of the room is covered with them. It is the custom of the manufacturer, while this is going on, to introduce a sufficient amount of saturated pickle from the lime rooms to replace the evaporated water and thus keep the salt well covered.

Since the brine contains besides salt, ferrous carbonate and gypsum, other constituents; namely, potassium, calcium and magnesium chlorides and magnesium bromide; a comparison of the chemical composition of the brine with that of the pickle is but proper in this place. From Dr. Goessmann's¹ experiments it appears that a brine having the chemical composition given under No. 1, produces a pickle of the composition given under No. 2.

	No. 1 Brine	No. 2 Pickle
Specific Gravity.....	1.1225	1.2062
Calcium Sulphate.....	0.5772 per cent	0.4110 per cent
Calcium Chloride.....	0.1533 " "	0.2487 " "
Magnesium Chloride.....	0.1444 " "	0.2343 " "
Potassium Chloride.....	0.0119 " "	0.0194 " "
Magnesium Bromide.....	0.0024 " "	0.0039 " "
Ferrous Carbonate.....	0.0044 " "	
Sodium Chloride.....	15.5317 " "	25.7339 " "
Water.....	83.5747 " "	73.3488 " "

In this experiment Dr. Goessmann employed 1010 parts of the above brine and obtained 623 parts of pickle, while 3.28 parts of calcium sulphate had crystallized out and 383 parts of water evaporated. While, then, the ferrous carbonate had been entirely removed and the calcium sulphate decreased by more than one half, the salt and the soluble calcium and magnesium chlorides had increased in the proportion of their original quantities. Whenever a sufficient amount of salt has accumulated in the salt rooms it is harvested. This occurs about three times during a season. The process consists in raking it together on the side of the room next to the road and putting it into small perforated tubs, to drain off as well as possible the adhering calcium and magnesium chlorides, since they impart to the salt a sharp bitter taste and keep it from becoming properly dry, as they are very deliquescent, absorbing moisture rapidly from the air. This being accomplished the salt is dumped into the salt cart and drawn to the store house. Since the gathered salt consists of crystals of various sizes, many manufacturers pass it as it comes from the salt yard (the name given to these works) into the store house, over a wire screen with 2½ meshes to the square inch, kept in motion by hand or steam power. While the unscreened salt is called "Standard Coarse," that which passes over the screen is known as "Diamond C," and the portion passing through the meshes "Diamond F."

Of the three kinds of rooms belonging to a salt yard about one-third are deep and lime rooms, the rest are salt rooms. These rooms are usually 18 feet wide; their length depends often on the extent of the yard, and it may be therefore from 100 to 500 feet and more. In a properly constructed salt yard, where the salt rooms are of great length, they are built in a number of sections in such a manner that the floor of the first is some 6 or 8 inches higher than that of the

¹Report on the Manufacture of Solar Salt, etc., Syracuse, 1864.

next one, and the floor of this one again the same number of inches higher than the third one and so on. The advantage of this arrangement is obvious, for it enables the manufacturer to keep the fresher pickles separated from the older ones, since, when the time of harvesting arrives he can discharge the pickle from the section above less charged with the deliquescent chlorides, for the purpose of removing as far as possible from the salt with this newer pickle the adhering chlorides and fine needle like gypsum crystals.

The depth of the rooms varies from 6 inches for lime and salt rooms to 12 and 14 inches for deep rooms. The movable covers are in 16-foot sections, capable of protecting a space of 16 X 18 feet square or 288 square feet. The size of the yard is estimated by the number of covers it has. During fair weather the covers are pushed aside on wooden frames constructed for that purpose beside the rooms."

The method employed at Syracuse to cover all the salt rooms when it rains is quite original. At the slightest sign of rain the company blows a whistle and all the population of the surrounding district—men, women, and children—turn out, with the result that in very short time all the covers have been moved. A similar operation is repeated when the vats are to be again exposed.

Few improvements have been made in these salt yards and they have remained almost the same as originally designed many years ago. One important improvement, however, has been effected in this system, by means of which the evaporation power has been increased by nearly one-third. Dr. Englehardt goes on to describe this improvement as follows:—

Solar Salt "Aprons."

"Within the last 15 years, the Onondaga solar salt manufacturers have adopted a plan by which some of them have increased their evaporating surface to a considerable extent, namely, they have added to their works, according to the space at their disposal, very large shallow vats from 20 to 100 feet wide by 200 to 2,000 feet long and about 3 inches deep. Wherever practicable they are erected over the deep rooms (serving instead of roofs) thus making the latter practically store rooms. These vats or aprons, as they are called, are built in a similar manner to the vats previously described, on piles or posts. At certain distances from each other are two sets of holes provided with wooden plugs. The surface of these flat vats is so constructed that any brine or rain water on them will run rather slowly towards these holes. One set of holes communicates with the deep room. During fair weather a small quantity of brine is allowed to run into these vats, not exceeding one half inch in height, and it often becomes entirely saturated in one day, when it is discharged into the deep room below, and its place is taken by a fresh portion of brine to be evaporated. In case rain is expected the plugs over the deep rooms or cisterns are drawn, the brine runs off, the plugs are again inserted and those drawn out of the other holes, through which the rain water runs off.

¹Ibid. p. 43-44.

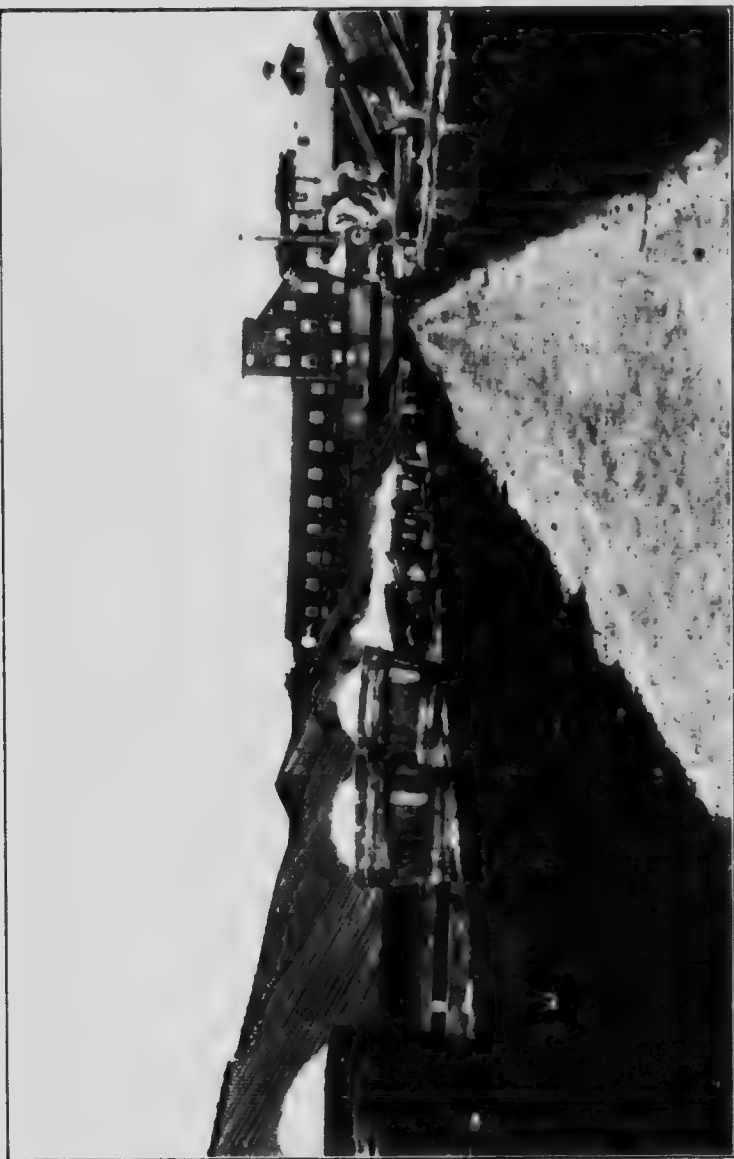
PLATE XVIII.



"Covers," Salina Salt Co., Syracuse, New York.

Photo by W. C. Phalen,
U. S. Geological Survey.

PLATE XIX.



Gathering solar salt, Salina Salt Co.'s yard, near Syracuse, New York.

*Photo by W. C. Phalen,
U. S. Geological Survey.*

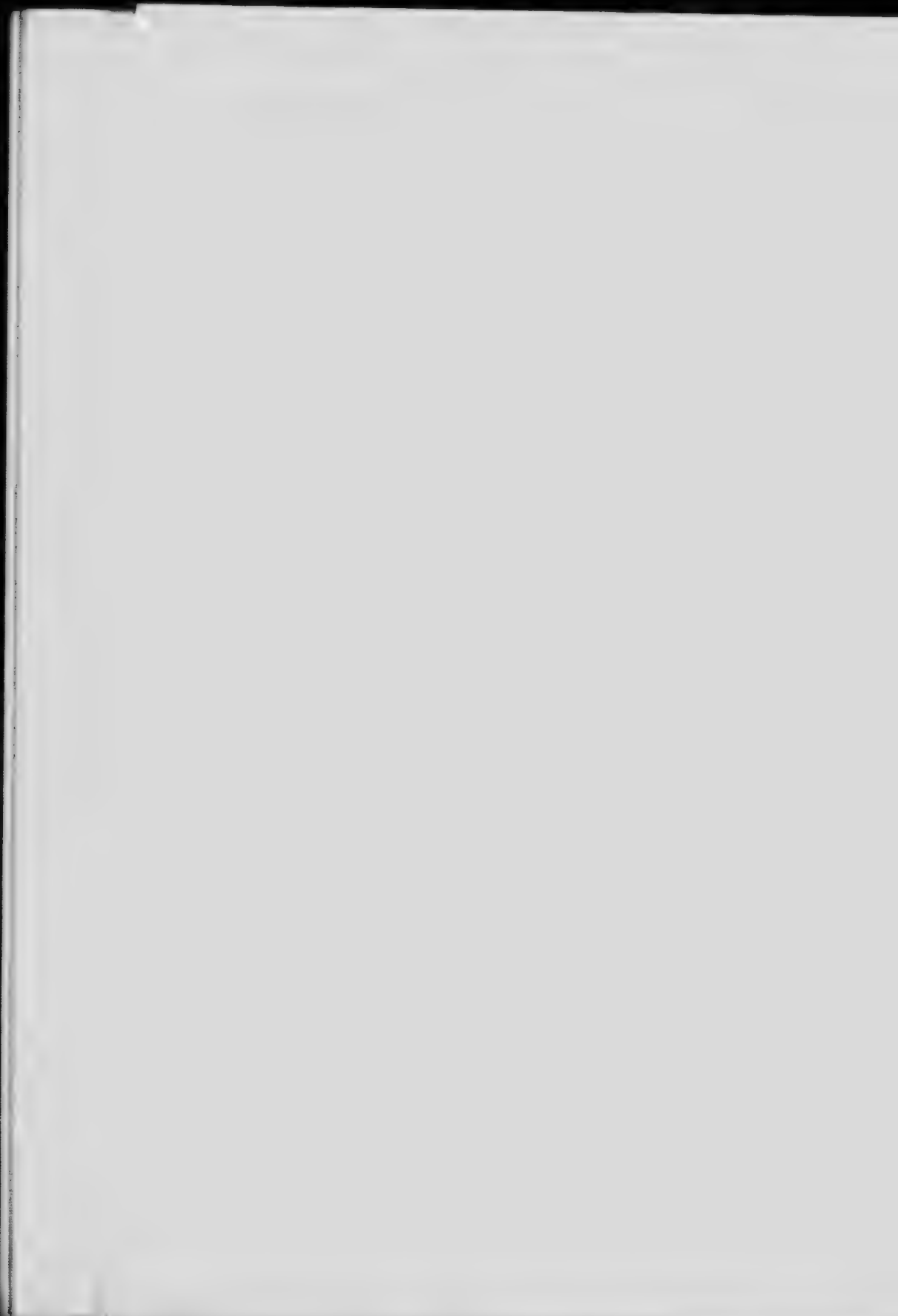


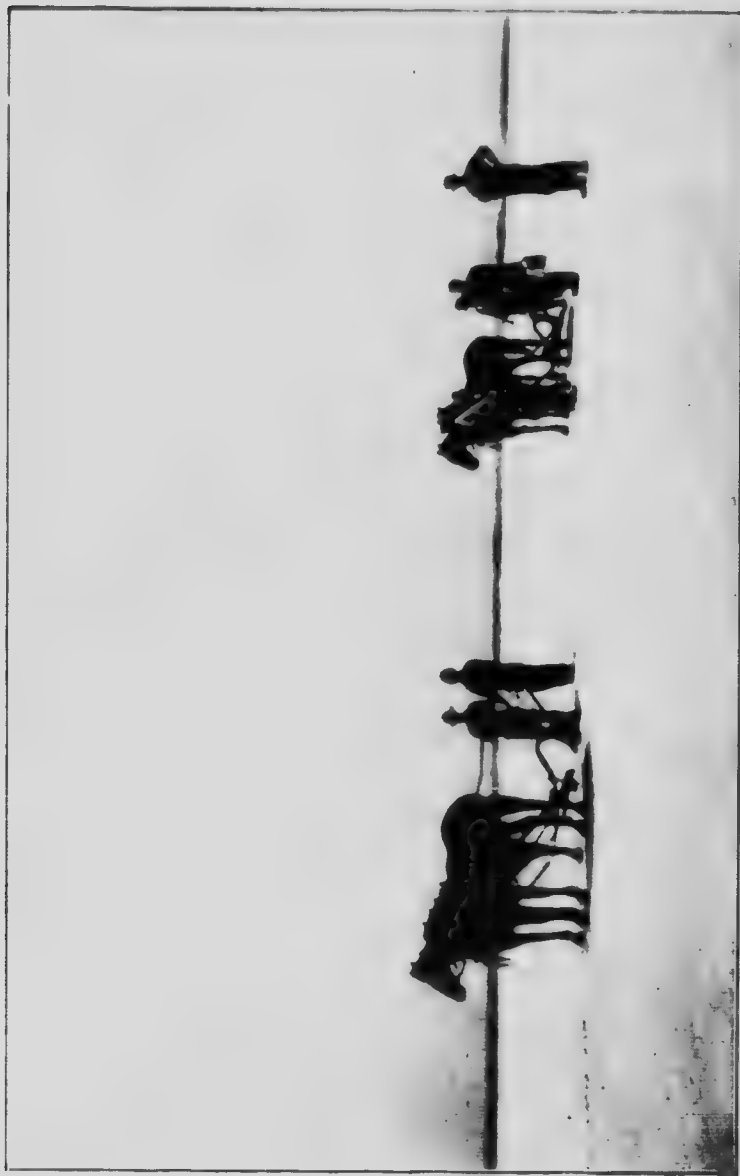
PLATE XX.



Loading solar salt on to cars for shipment to plant, Inland Crystal Salt Co.,
Saltair, shore of Great Salt Lake, near Salt Lake City, Utah.

Photo by W. C. Phelps,
U. S. Geological Survey.





Ploughing salt in harvesting pond, Inland Crystal Salt Co., Saltair,
shore of Great Salt lake, near Salt Lake City, Utah.

Photo by W. C. Phelan.
U. S. Geological Survey.

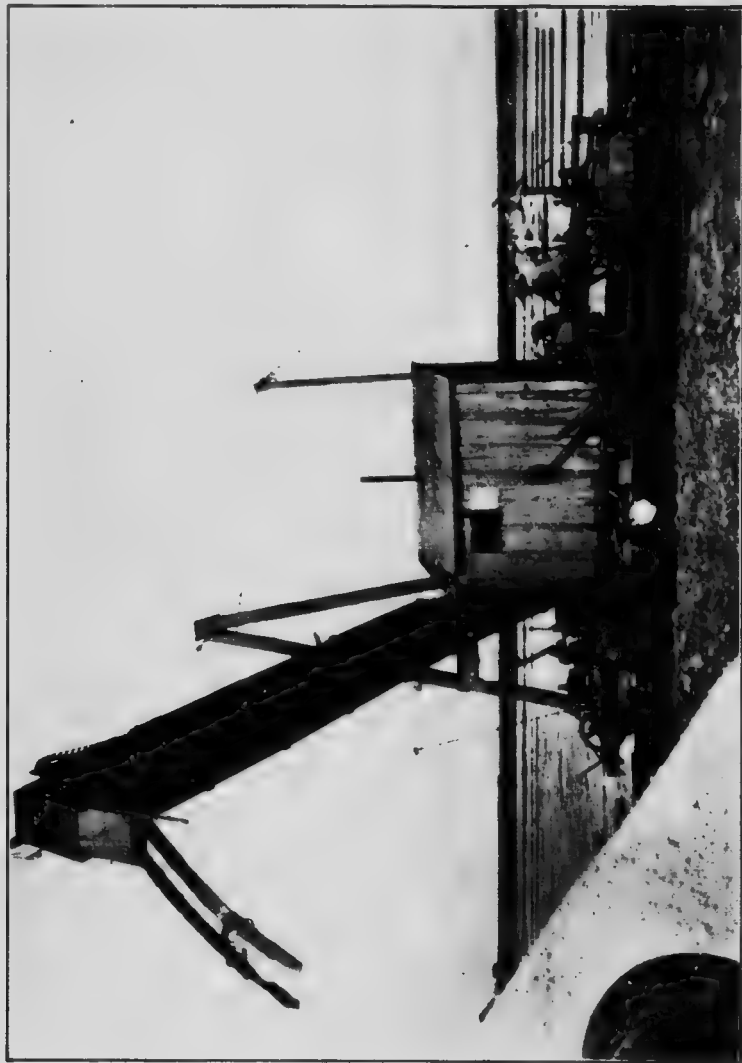
PLATE XXII.



Loading solar salt at the Oliver Salt Co.'s plant, Mt. Eden, California.

Photo by W. C. Phalen,
U. S. Geological Survey.

PLATE XXIII.



Showing one method of lifting salt from ponds,
California Salt Co., Alvarado, California.

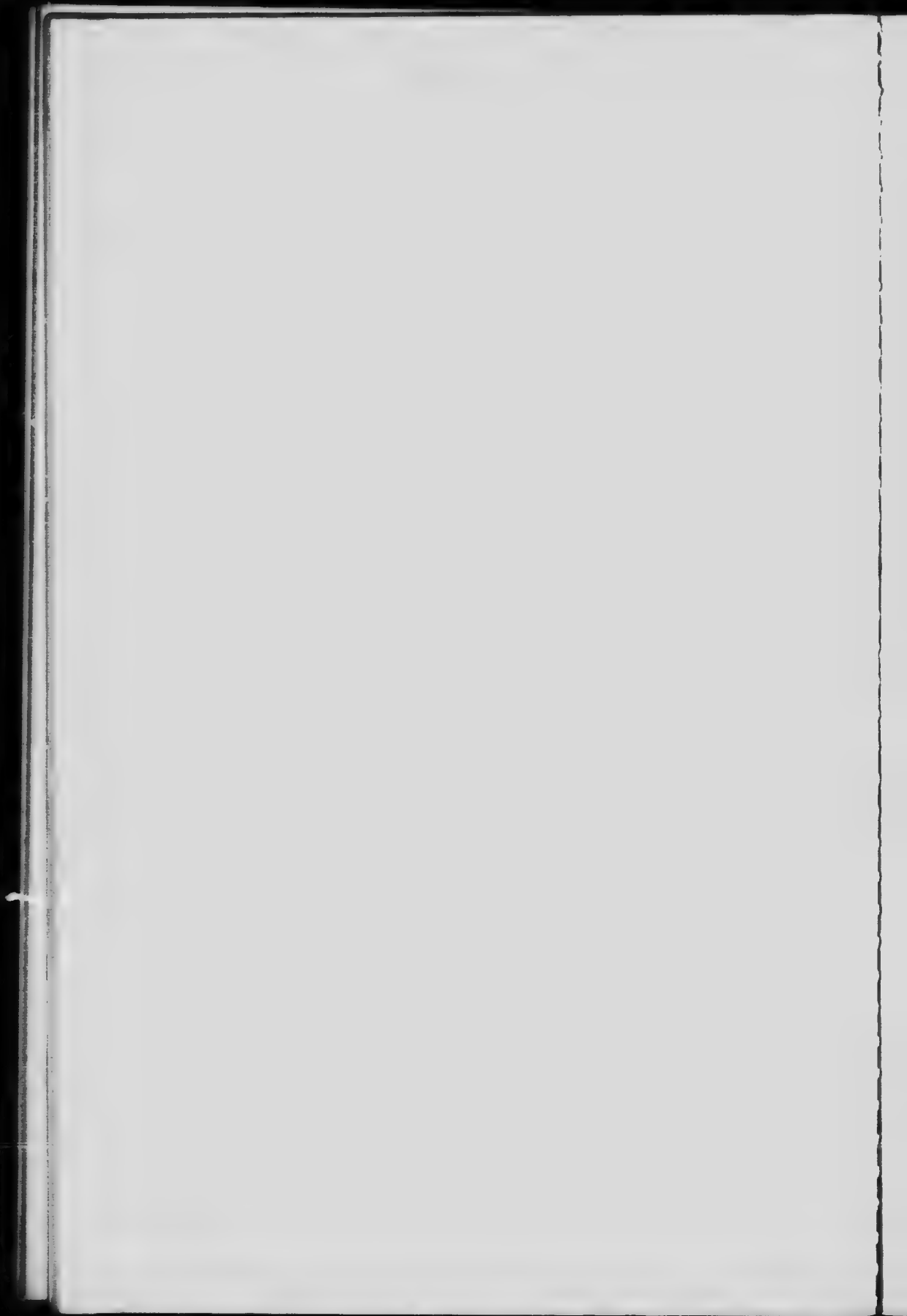
*Photo by W. C. Phalen,
U. S. Geological Survey.*

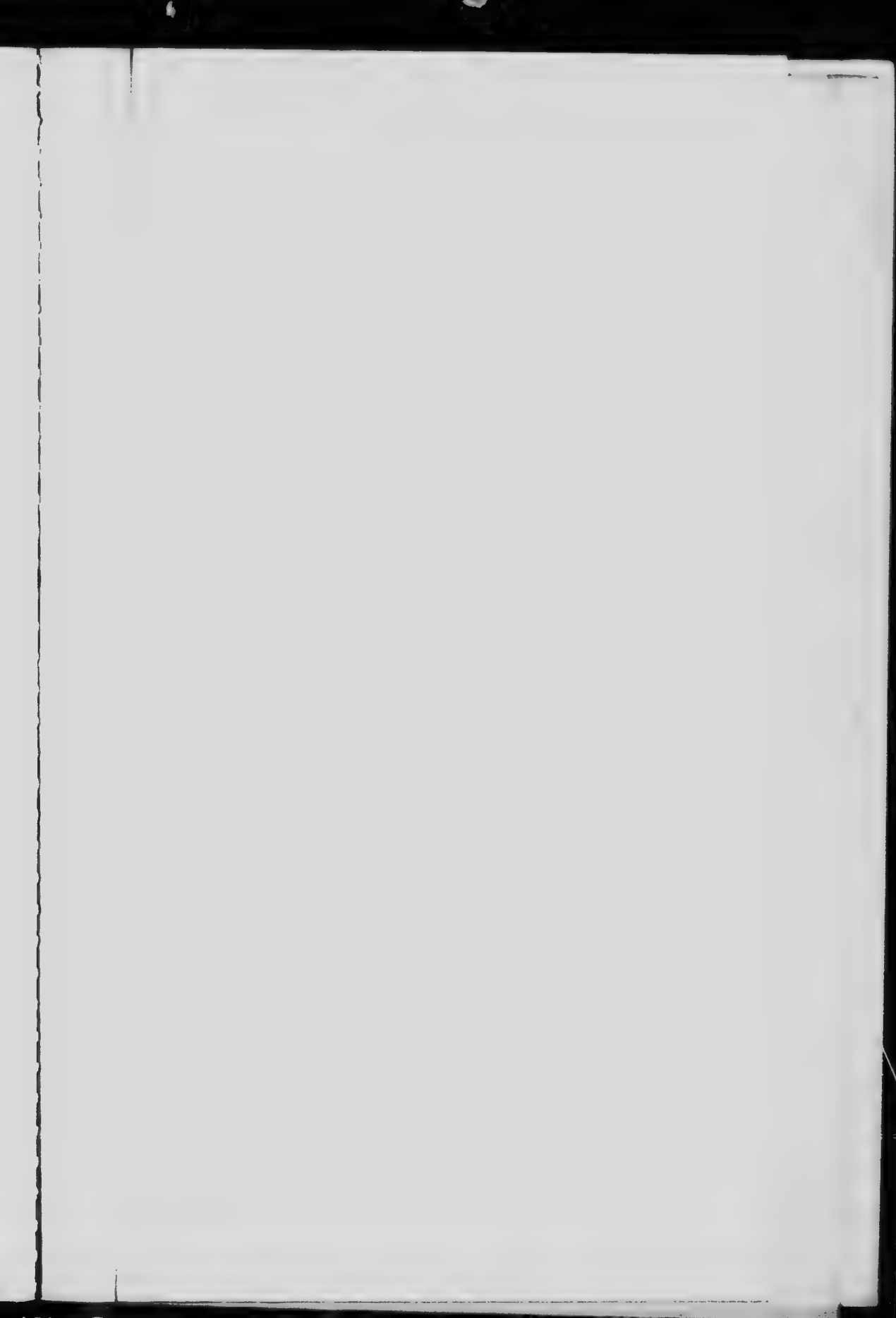
PLATE XXIV.



View of crystallizing pond, showing one field ready to harvest,
Leslie Salt Co., San Mateo, California.

*Photo by W. C. Phalen,
U. S. Geological Survey.*







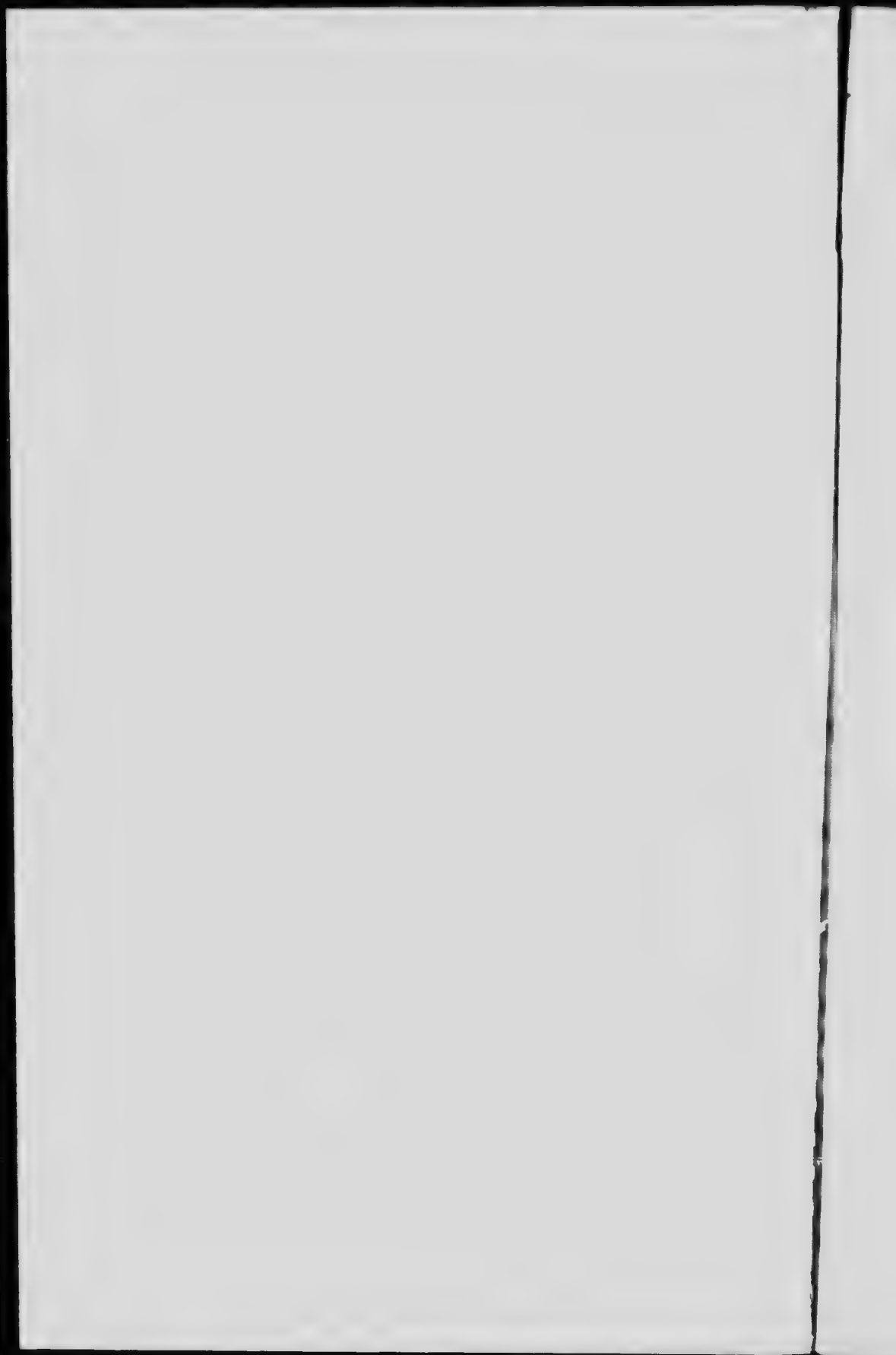
Panoramic view, showing solar salt fields after stacking salt,

PLATE XXV.



ucking salt, Long Beach Salt Co., Long Beach, California.

Photo by W. C. Phalen, U. S. Geological Survey.



The advantages of this method are: first, a much more rapid evaporation due to the shallow layer of brine, and secondly, the gain of all the lime rooms for salt rooms. Ordinarily a solar salt yard with 2,700 "covers" 10×18 feet square consists of 1,800 salt rooms, 800 lime rooms and 100 deep rooms. By this improvement the salt rooms are increased to 2,600. Moreover, the iron (ferrous carbonate) and the sulphate of lime (calcium sulphate) separate very quickly. When rain prevents the lime from becoming saturated, before it is discharged into the deep rooms or cisterns, it is returned to these aprons by a pump. The increase in the yield of salt per cover by this method over the old one is about 15 to 20 bushels per season according to the size of the aprons belonging to a yard.

The amount of salt produced in a solar field during a season depends not only on the state of the weather but also on the composition of the pickle from which the salt is deposited, since if the latter is too highly charged with calcium and magnesium chlorides due to keeping the old pickle over from season to season, evaporation may be greatly retarded thereby; in fact it may cease almost entirely, since whatever evaporation of water may take place in clear warm water from a pickle overcharged with these chlorides, will be re-absorbed again by them during the prevalence of a damp, moist atmosphere. The quality of the salt depends on the weather to a certain extent, but mainly on the intelligence and care of the workman. Supplying the salt rooms with perfectly saturated pickle, allowing the harvested salt (after properly washing it with newer pickle from the section above to remove adhering gypsum crystals and chlorides) to drain properly both in the tub and the storehouse and finally to discharge the old pickle at the proper time are of the utmost importance in the manufacture of a good commercial, solar salt."

The name "solar salt" is more particularly applied to salt produced by solar evaporation at Syracuse and other places, where wooden vats are employed; in contradistinction to "bay salt" the name given to that made by the evaporation of sea water in shallow pits on the sea shore, as already described.

The methods employed at Syracuse entails a large initial expenditure, on account of the great quantities of lumber required in the construction of the vats. As an industry it is also very precarious owing to the results being altogether dependent on climatic conditions, so if the summer season is a wet one the salt harvest is practically a failure. This fact, together with the large amount of capital necessarily tied up in lumber in the vats and covers, has gradually caused the method to be less and less employed, and solar evaporation is now only made use of where the climatic conditions are ideal, or where the vats, built many years ago, are still in serviceable condition.

Plates XVIII to XXV inclusive, were furnished by the kindness of Mr. W. C. Phalen of the U. S. Geological Survey, and form a splendid series, illustrating all the different phases of solar evaporation.

Artificial Heat Evaporation.

From the earliest times salt was recovered from brines by means of artificial heat applied to vessels in which brine was contained. The earliest methods were naturally crude, but improvements have been continually made, and in late years the industry has made rapid progress in the line of machinery for cheap evaporation. Evaporating methods in which artificial heat is employed, fall naturally into two groups, according to whether the heat is applied directly, as in the case of the open pan or kettle process, or indirectly in the form of steam circulating through pipes.

Direct Fire Evaporation.

Kettle Process. One of the earliest methods employed in the salt industry consisted in evaporating the brine in large hemispherical kettles, over an open wood fire. An improvement was shortly made in this method by setting the kettle in an arch of masonry. Later, two kettles were employed, then four, using the same fire, and finally, the kettles were placed in long rows, as high as 30 or 40 in each row; with one common fire box, and a common stack for several rows. The salt formed was removed by hand, and placed in baskets to drain. The method was, at best, very wasteful of fuel, since in order to heat the kettles furthest away from the fire box, heavy fires had to be made, and this caused an excessive heat under the nearest kettles. Naturally, on account of this difference in heat under the different kettles, a uniform grade of salt could not be obtained. Due, therefore, to these, and several other drawbacks, the kettle method of evaporation was gradually replaced by the English open pan method.

Pan Process. As first adopted in Canada—upon rejection of the kettle method, the pan employed consisted of a long shallow pan placed upon two walls, with a fire-place at one end and a chimney at the other. These pans were made of $\frac{1}{4}$ " boiler plate, and were from 40 to 50 feet long, 12 to 20 feet wide, and 10 to 12 inches deep. One fire grate was used, and the

products of combustion passed under the pan, and directly up the chimney. The best practice of the present at plants where the open-pan method is employed is, to have two or four pans in one "block," as these salt plants are called. If, for example, four pans are employed, they are arranged in pairs, side by side; the pairs being placed end to end, so that one common chimney or stack is utilized for all four pans. Where the furnace gases pass under the length of the pan, and are then allowed to escape, the pan is generally divided into two compartments, two grades of salt being made in each pan: fine salt in the compartment nearer the fire grate, and coarse salt in the compartment farther from the fire, where evaporation is much slower. An arrangement by which an even grade of salt is made throughout the pan is, to divide the space underneath the pan into three chambers, and to allow the furnace gases to pass through the two outside ones, and return to the stack by the middle flue. The stack in this case is located beside the fire grate. This system has, in the case of a "block" of four pans, the advantage that all the fire boxes are situated on either side of one passage way, and can be attended to much more easily than if two were at either end.

The pans are made of $\frac{1}{4}$ " boiler plate rivetted together. The length varies from 90 to 120 feet, and the width from 18 to 24 feet, with a depth of 12 to 14 inches. The salt is removed as fast as it is formed by means of long scrapers. Between the two pans a walk, 6 to 8 feet wide, is placed, from which the man operates the rake. The sides of the pan are generally sloping, and bolted to the drainage boards (6 feet wide). The salt can then be raked directly from the pans on to the boards, and left there till thoroughly drained, before being removed in two wheeled carts to the drying bins. It is necessary that the salt be removed at frequent intervals, so that it will not cake on the bottom of the pan, and thus retard the conduction of the heat through the pan to the brine, or injure the quality of the product. If the brine is not agitated frequently by the removal of the salt by these rakes, there is a tendency for a film of crystallized salt to form on the surface of the brine as a scum, and thus prevent the escape of the steam of evaporation. The open pan method is employed in a number of the Canadian plants.

Steam Evaporation.

The fact that the preparation of salt by the open pan system was extravagant in fuel, and that the product obtained varied considerably, led to the adoption of other methods which utilized either exhaust or live steam.

The Steam Jacket.

The earliest use of steam in the salt industry was in steam jackets surrounding the kettles or pans of the kettle and open pan processes. A second bottom was placed under the kettle or pan, through which steam, either live or exhaust, was allowed to circulate. This produced a constant temperature in the evaporator, and thus an even product was obtained. The grainer system and the vacuum pan, however, produce the same results, and are much more economical; so that in nearly all the best plants, these processes are employed.

GRAINER SYSTEM.

Grainers consist, in general, of shallow vats of various shapes, near the bottom of which a series of steam pipes are placed, through which steam is allowed to circulate, and heat the brine. These vats are generally rectangular in shape, with a depth of from 18 to 24 inches, a width of from 8 to 16 feet, and a length of from 60 to 120 feet. They may be built either of wood, lined with tile for protection, cement, or steel.¹

The pipes are arranged after the manner of ordinary heating coils, so that the steam entering at one end passes through the whole series of coils before leaving the grainer. The pipes are generally 2" diameter.

In best practice the salt is removed from the grainers by some continuous, operating form of mechanical rake. The two types most commonly used are the endless chain raker,

¹One variation in the grainer type that is quite common is the shaped grainer. In this type a scraper conveyer runs along the bottom of the vat and scrapes the salt as formed to the end of the evaporator, where it is removed by an elevator. The pipes are placed above this conveyer.

and the reciprocating raker. In the former style of rake the lugs on the chain drag along the bottom of the grainer, carrying the salt with it, and deposit it on the inclined draining board at the end. This rake has the disadvantage of having the chain exposed to the corrosive action of the air while returning to the front of the grainer and the rust so formed is liable to discolour the salt. In the reciprocating rake, a rigid frame is operated back and forth on angle ledges on the sides of the grainer, the lugs on which frame are so fastened that on the back stroke they trail over the top of the salt and only push the salt along the bottom and up the incline on the forward stroke. The reciprocating motion is obtained by means of a hydraulic cylinder placed at the end of the grainer. The salt is thus shoved gradually up the draining board, from the top of which it falls into a trough, through which a conveyer runs, and carries it to the drying bins.

These grainers may use either live or exhaust steam. The temperature can be regulated at will, so that the grainer can be made to produce whatever grade of salt is required.

Vacuum Pan Evaporation.

The application of the vacuum pan process to the manufacture of salt is a comparatively new departure. Although vacuum pans have been employed for many years in the sugar and other similar industries, it was not until the year 1887 that the first vacuum pan for the manufacture of salt was placed in operation. This pan was erected by Mr. Joseph Duncan at Silver Springs, N.Y. From that time their use has extended with gradual improvements, to all the more modern plants on the American continent.

The principle upon which the vacuum pan process is based is, that, when the pressure on the surface of the brine is decreased, the boiling point of the brine is correspondingly lowered. The brine can then be evaporated with a great saving in the amount of heat required. The heating medium employed in evaporation of the vacuum type, is steam, either live or exhaust. No vacuum evaporators have been, so far, designed to successfully operate by direct heat.

Vacuum evaporators may be operated in series as double effect, triple effect, quadruple effect, etc. When the pans are employed in this manner, the steam formed by the evaporation of the brine in the first pan is conducted to the heating chamber in the second pan, in which a greater vacuum is carried. Likewise, the steam generated from the brine in the second pan is led to the steam chamber in the third pan, where a still greater vacuum is maintained. Similarly, each pan is heated by the steam produced in the preceding pan, for as many pans as are operated in series. The steam from the last pan is carried to a condenser. The vacuum in each pan is created by the condensation of the steam in each succeeding steam chamber, the vacuum in the last pan being produced by a vacuum pump.

The construction of the several types of evaporators employed in the salt industry varies only in a few minor details. They consist essentially of four parts, namely:—

- (1) the evaporating and condensing chambers,
- (2) the heating element,
- (3) the coned bottom,
- (4) salt filter, or barometric leg.

EVAPORATING AND CONDENSING CHAMBERS.

The main body of the evaporator may be built of steel, cast iron, or copper, generally circular in cross section, and either cone, or dome-shaped at the top. The height of this chamber varies with the diameter, and is made sufficiently high to prevent the escape of any of the brine by entrainment, or foaming. In order to prevent a loss of heat by radiation, the evaporation chamber is covered completely (as well as all other parts of the evaporator) with a heavy coating of asbestos packing. The condensing chamber is of the usual type, furnished with a vacuum pump.¹

THE HEATING ELEMENT.

Two methods of applying heat to evaporate the brine are employed. In the first, a steam chamber is placed between

¹When working in double or multiple effect, the heating element or steam chest of the succeeding unit is the condensing chamber for the preceding evaporator.

the evaporating chamber and the coned bottom, in which a series of copper tubes, varying from two to four inches in diameter, are fastened vertically in the top and bottom plates of the chamber. These tubes are open at either end, and thus permit free circulation of the brine between the cone-shaped bottom, and the evaporating chamber. The steam is passed into this chamber, and circulates in and out around the tubes, thus heating the brine circulating within them. The condensed steam is drawn off by suitable means from the bottom of the steam chest. The second method employed in heating the brine is to have the steam pass through a series of coils, or tubes, around which the brine has free circulation. In this method of heating, special means have to be adopted to properly dispose of the condensed steam, and the coils of pipe have to be so arranged as not to impede the salt, as it is formed, from descending into the cone-shaped bottom.

One of the great difficulties encountered in the application of vacuum pans to salt manufacture is the scale which deposits upon the heating surface.¹ This has to be removed at frequent intervals, or else the evaporative capacity of the pan will be greatly reduced. In order to facilitate the removal of this scale, the heating element should be either removable from the pan, or else easily accessible.

THE CONE-SHAPED BOTTOM.

The bottom of the pan is sharply coned, so that the salt crystals, as formed, may readily fall to the bottom, clear of the heating tubes, and can then be drawn off from time to time. The pipe for the entry of the brine is generally attached to this cone.

THE SALT FILTER, OR BAROMETRIC LEG.

In order that the operation may be continuous, there must be some means of removing the crystals of salt as fast as they are formed. This is accomplished in two ways, (1) by a salt filter, (2) by a barometric leg. In using a salt filter, the salt is drawn

¹This scale is, in most cases, composed of calcium sulphate, which is present in the original brine, and in the best practice this is largely removed before the brine enters the evaporators.

off into a filter or chamber, connected with the cone bottom. The connecting valve is closed when the filter is filled, and the salt is removed without stopping the operation of the evaporator. Sometimes two pipes lead from the cone to two filters, so that, when one filter is being emptied, the valve to the second is opened and allowed to fill. This prevents any possibility of clogging of the salt crystals in the bottom of the cone. In the barometric leg the salt falls continuously down, and is removed from the bottom by a closed elevator. This method is very efficient, when working on a large scale.

The salt made in vacuum pan evaporators is mostly of a very fine grain, and, consequently, has not entirely succeeded in replacing the grainer, the latter being able to produce varying grades of salt, according to the amount of heat supplied.

In order to give a general idea of the construction and operation of vacuum evaporators, several well-known types are herein described.

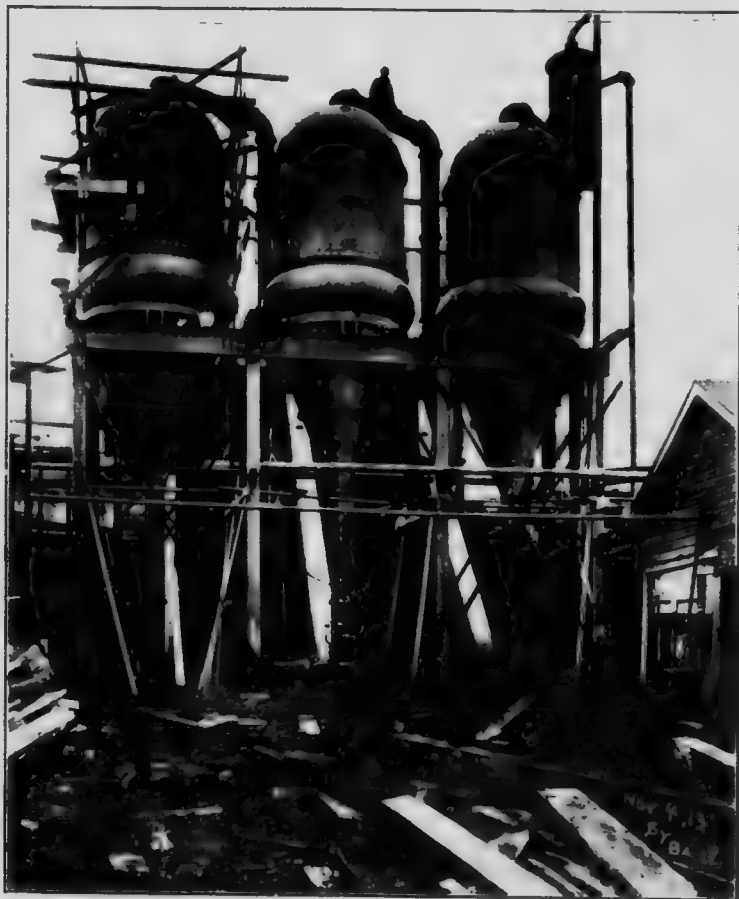
The Swenson Evaporator.

The Swenson evaporator is manufactured by the Swenson Evaporator Company, of Chicago, Ill., U.S.A. By referring to Fig. 21, which gives the plan and elevation of a triple effect Swenson evaporator, the general details of the construction and erection can be readily seen. Plate No. XXVI shows a recent installation in the United States of one of these evaporators.

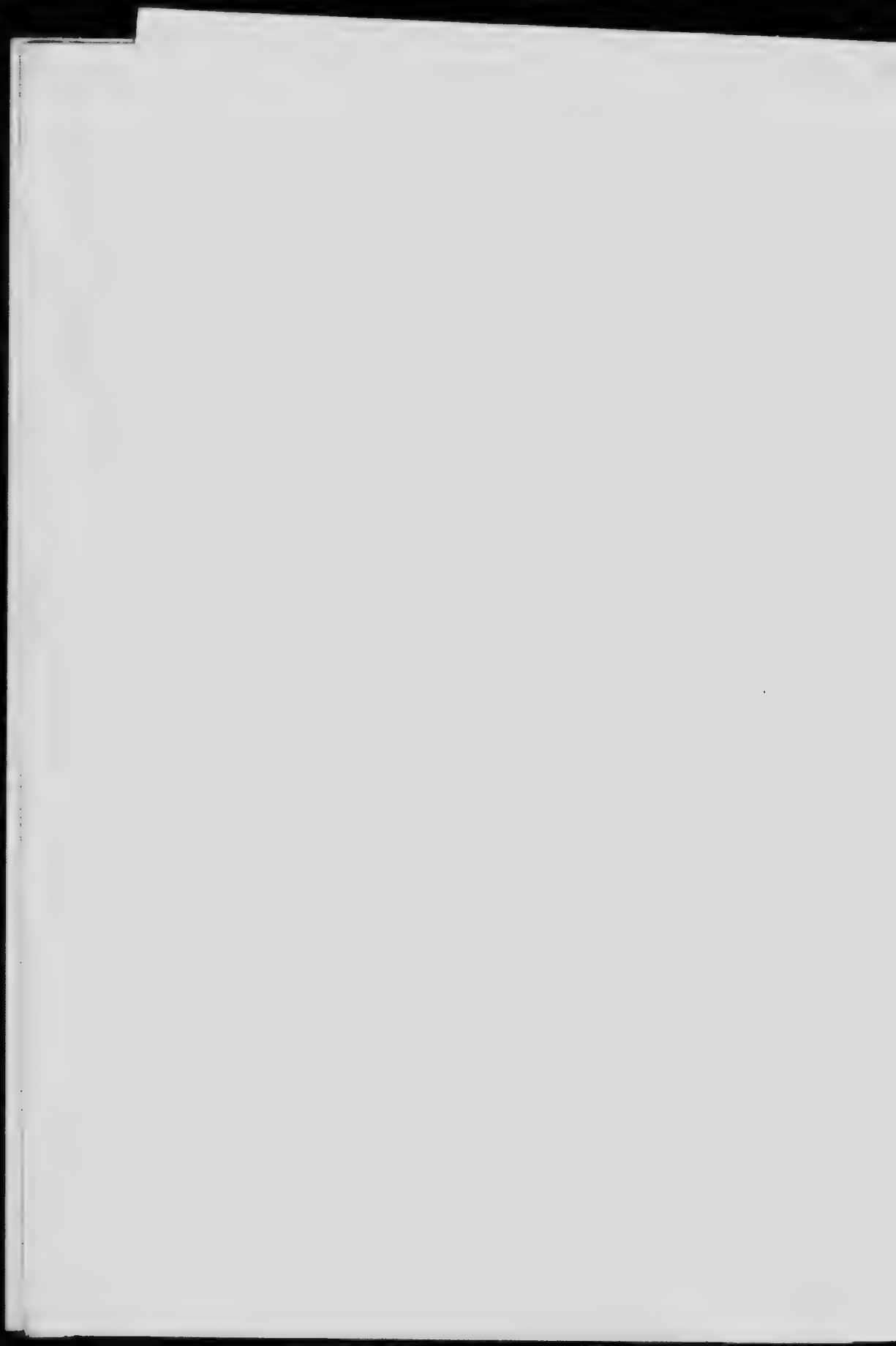
Construction.

The evaporator consists of four essential parts; (1) the evaporating dome; (2) the steam chest; (3) the cone-shaped bottom, and (4) the barometric leg. The evaporating chamber is dome shaped and of sufficient height to prevent loss by entrainment. The steam chest is fitted at the top and bottom with tube plates, into which are expanded a number of $2\frac{1}{2}$ " copper tubes. The downtake is in the centre of the steam chest, and is of sufficient size to prevent the clogging of the salt crystals as they are formed. The brine circulates up through the copper

PLATE XXVI.



Swenson triple effect evaporator in course of erection, United States.



tubes and down the central downtake. The salt crystals, as formed, drop into the quieter part of the cone-shaped bottom, and drop right down the barometric leg into the boot of an enclosed elevator, which drops them into the drying bin.

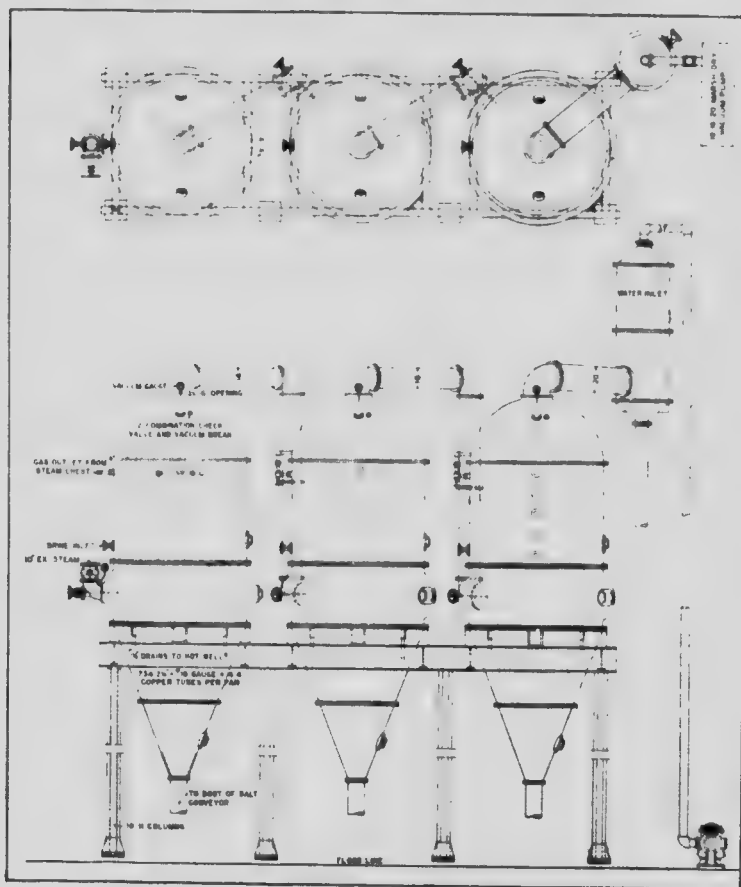


Fig. 21. Swenson triple effect evaporator.

Operation.

The operation of an evaporator of this type is continuous, and similar to the general description already given. Suitable means are provided for the removal of the enclosed gas in the

steam chest as well as the condensed steam. The evaporators can be operated either as single or multiple effect.

The Mantius Crystallizing Evaporator.

The Mantius crystallizing evaporator is manufactured and sold by the Zaremba Company, Buffalo, N.Y.

Construction.

These evaporators consist of two parts: (1) an evaporator body, in which the evaporation occurs; (2) a salt filter underneath, by means of which the precipitated crystals are separated from the concentrated liquor, washed clean, and removed from the system.

The shell of the evaporator body is built of heavy cast iron or steel. Its lower portion, below the heating surface, consists of a cone into which the salt is precipitated and funnelled into the salt filter below. Mounted within the shell immediately above the cone is the cylindrical steam chest, fitted at top and bottom with disked heads of steel, into which 2" charcoal iron tubes are expanded. These tubes are slightly inclined from the vertical, to facilitate the circulation and prevent possible loss of liquor. Copper tubes may be substituted if preferred.

The downtake is an annular opening, widest at the bottom, extending entirely around the steam chest. Circulation of liquor is upward through the tubes; outwards toward top of downtake; downward between steam chest and exterior shell; then inward to lower end of tubes. This action produces a ready separation of the salt crystals from the boiling liquor, throwing them into a zone of quiet in the conical bottom, and thence into the salt filter.

The filter consists of a cylindrical cast iron chamber, fitted with a filter screen, supported about eighteen inches above the bottom. At the front, and immediately above the screen, is a swinging door through which the separated salt is removed. The conditions inside can be observed through the sight glass. The sh

ators

and

erator
under-
ated
from

cast
face,
fun-
shell
tted
a 2"
htly
pre-
uted

om,
of
o of
hen
ady
ying
into

tted
the
is a
The
sh

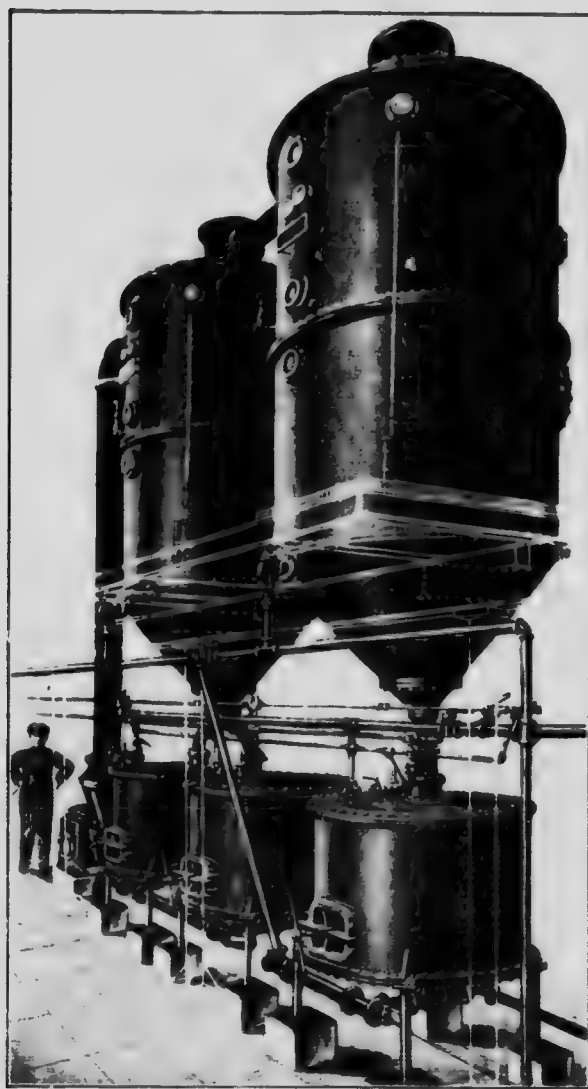


Fig. 22. Mantius Evaporator.



water is introduced through perforated pipes mounted under the top cover of the filter. An asbestos-packed plug cock is placed between the evaporator and the filter, whereby communication between the two can be closed when necessary. The filter is fitted with connexions for water, steam, air, and vacuum, and heavy liquor. Suitable vacuum and liquor pumps are connected to the system, to provide for all requirements.

METHOD OF OPERATING A DOUBLE EFFECT MANTIS EVAPORATOR.

The brine enters the first effect (in foreground Fig. 22) at top of cone, and flows to the base of the steam chest. By the action of the vapour generated in the tubes, and the pressure exerted by the liquor in the downtake, a vigorous movement is set up within the tubes (about 30 feet per second), inducing rapid heat transmission, and violent scouring action on the interior of the tubes. Owing to the large area of the downtake, the return flow to the bottom of the steam chest is very slow (about 3 feet per second or less), allowing the crystals formed during the concentration to separate from the liquor, and drop gently into the zone of unagitated liquor contained in the cones. These crystals drop to the bottom of the cones and pass through the plug cock at tip of cone and into the salt filter.

A liquor line connects the bottom outlet of the filter to the liquor inlet of the second effect, which, being under a higher vacuum, draws the liquor through the filter, and into the liquor inlet by suction. The suspended crystals are left behind on the filter screen, where they are allowed to accumulate until the salt filter is filled (determined by sight glass). The connexion between the evaporator and the filter is now shut off by closing the plug cock between them; and after drawing off the excess brine, the contents of the filter are washed and dried by compressed air. The connexion to the second effect is then closed, the discharge door of the filter is opened, and the thoroughly washed crystals are removed in an approximately dry condition.

After the filter has been emptied, its door is closed, and the contained air removed, by replacing it with steam. The con-

densation of this steam will soon produce sufficient vacuum to pull the mixture of brine and salt collected in the cone down into the filter when the plug cock is opened. The brine level in the evaporator is again brought to standard height, and the filter placed in circuit by opening the connexion to the next effect. When the amount of salt precipitated is comparatively large, two filters are attached to one evaporator body, thus making it possible always to have one filter connected to the evaporator, inasmuch as the filters are used alternately. By either arrangement, the salt is dried and removed without interfering with the work of the evaporator above.

The method of operation in the second effect is the same as that described in the case of the first effect, except that the brine from the salt filter is drawn off by the suction of a pump. The brine discharged from this pump is returned to the second effect to be recirculated.

These evaporators are built as single, double, triple, and quadruple effects; and are generally connected in such a manner that any one of the bodies can be put out of service without interfering with the others.

A novel feature in these evaporators is that they are all equipped with internal separators, which makes impossible the carrying over of liquor by entrainment—due to carelessness in operation.

The steam pressure used, varies all the way from atmospheric to 60 pounds, or more, depending on circumstances. Ordinarily, direct acting pumps are furnished, their exhaust being delivered to the evaporator. It is claimed that salt, containing as low as 6 per cent moisture, can be discharged from these evaporators.

The Brecht Salting Evaporator.

The Brecht salting evaporator is manufactured by the Brecht Company, St. Louis, Mo., U. S. A., It can be operated in either single, or multiple effect, as required.

It consists essentially of three parts: (1.) the evaporator shell, (2.) the heating chamber, and (3.) the salt filter. See Fig. 23.

um to
down
level
d the
next
tively
thus
o the
By
thout

s the
t that
ump.
econd

, and
anner
thout

re all
le the
seness

atmos-
ances.
being
aining
evap-

y the
erated

erator
See

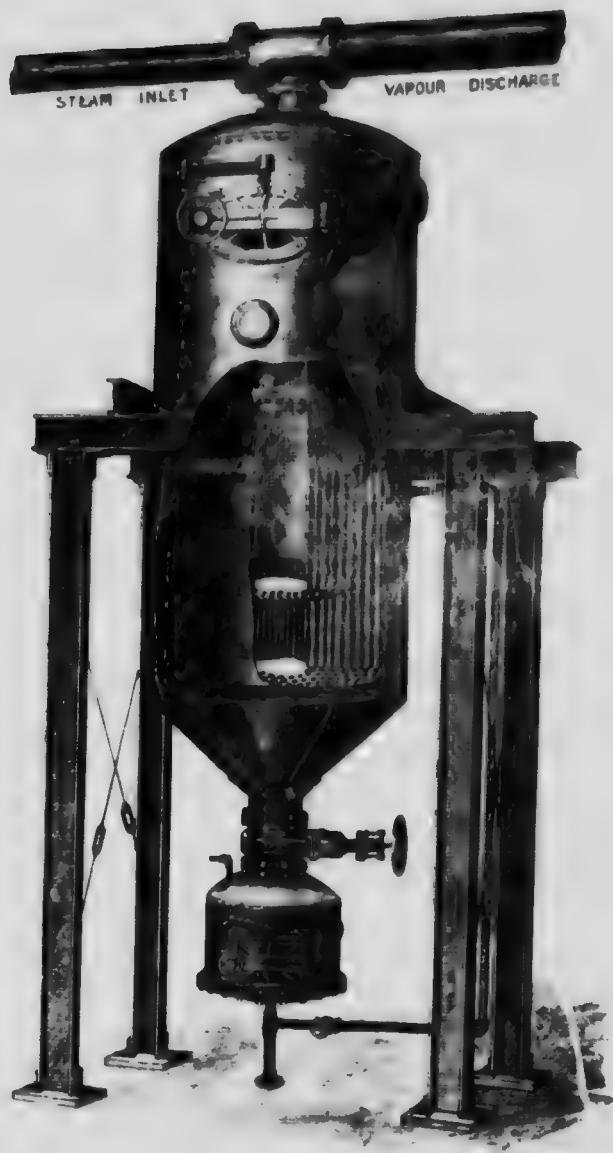


Fig. 23. Brecht Evaporator, with salt filter attached.



The Evaporator Shell.

This is made generally of steel, and is cylindrical in shape, with domed top, and cone shaped bottom. Suitable observation holes and water gauge are attached to the cylindrical body, and an air tight man hole is placed near the top.

The Heating Chamber.

The heating chamber is one of the essential features of this evaporator. It consists of a steam drum in which a number of steel or copper tubes are placed vertically. These tubes allow the brine in the evaporating chamber to circulate freely to the cone shaped bottom, and to return again to the upper part of the evaporator. The drum is cylindrical in shape, and fits within the steel shell, where it is suspended on lugs attached to the side. The steam from which the heat is obtained enters the top of the drum, and by means of a series of baffle plates so arranged that the direction of the steam travel is at right angles to the tubes, all the tubes are heated equally. The steam is thus constantly in circulation until it condenses and is drawn off by suitable means from the bottom of the drum. The tubes are made of either steel or copper, as required, and are 4" diameter, thus preventing any chance of clogging, as the salt crystals form.

The Salt Filter.

The salt filter is so constructed that the crystals of salt may be removed at any time without interfering with the process of evaporation. Connexions are provided on the filter so that steam or air may be introduced into the salt for the purpose of washing out the liquor, and drying the salt. The salt filters are built of cast iron, and the filtering medium is composed of perforated brass sheets, and fine brass wire cloth. Fig. 23 gives an idea of the appearance of a single effect evaporator of this type.

The following table, taken from the Brecht catalogue, gives a few of the measurements, etc., of one of these evaporators:

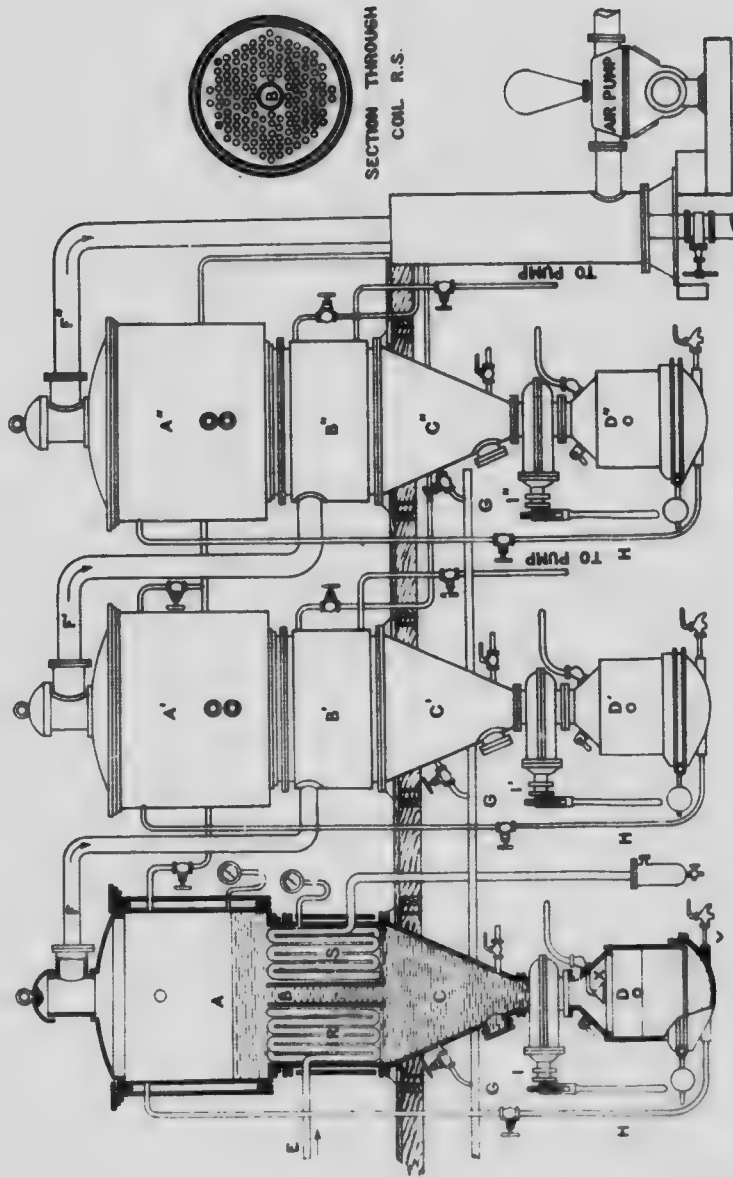


Fig. 24. Pick triple effect evaporator.
(After International Text Book Co.)

No.

1
3
5
7½
10
15
20

1
3
5
7½
10
15
20

1
3
5
7½
10
15
20

Prices include
steam tray
complete ✓

Plants cor
cost of 5 p

TABLE XIX.

Brecht's Standard Evaporator*Single Effect. Steel Shell. Steel Tubes.*

No.	Type.	Capacity Gallons per hour.	Exhaust Steam H. P.	Floor Space Square Ft.	Height over all.	Weight Pounds.	Cubic Feet Export.	Price.
1	S	100	28	16	9 ft. 6 in.	3,750	237	\$ 1,800.00
3	S	200 - 300	84	19	10 ft. 6 in.	4,750	330	2,375.00
5	S	400 - 500	110	23	10 ft. 6 in.	5,770	400	2,700.00
7½	S	650 - 750	210	28	12 ft. 6 in.	7,300	575	3,400.00
10	S	800 - 1,000	280	30	12 ft. 6 in.	9,240	625	3,700.00
15	S	1,200 - 1,500	420	45	12 ft. 6 in.	13,140	920	5,200.00
20	S	1,700 - 2,000	560	45	12 ft. 6 in.	15,400	920	5,700.00

Double Effect. Steel Shell. Steel Tubes.

1	S	100	14	38	9 ft. 6 in.	7,000	380	2,385.00
3	S	200 - 300	42	46	10 ft. 6 in.	8,900	533	3,285.00
5	S	400 - 500	70	54	10 ft. 6 in.	10,940	640	3,870.00
7½	S	650 - 750	105	68	12 ft. 6 in.	14,500	925	5,085.00
10	S	800 - 1,000	140	72	12 ft. 6 in.	17,500	1,000	5,800.00
15	S	1,200 - 1,500	210	102	12 ft. 6 in.	24,800	1,480	7,740.00
20	S	1,700 - 2,000	280	102	12 ft. 6 in.	29,300	1,480	8,640.00

Triple Effect. Steel Shell. Steel Tubes.

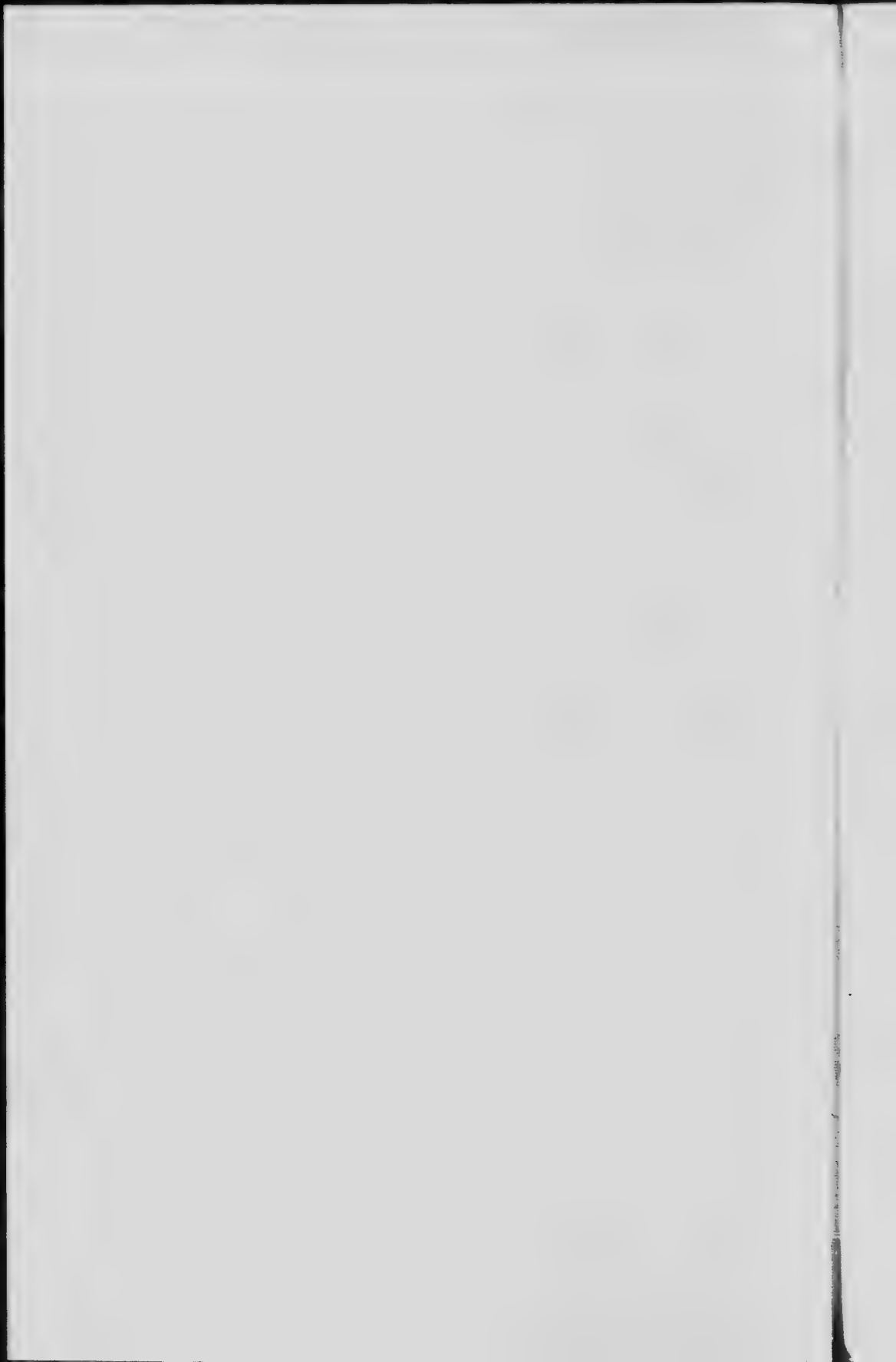
1	S	100	10	61	9 ft. 6 in.	10,250	650	2,970.00
3	S	200 - 300	30	73	10 ft. 6 in.	13,000	900	4,185.00
5	S	400 - 500	50	85	10 ft. 6 in.	16,000	1,070	5,200.00
7½	S	650 - 750	75	106	12 ft. 6 in.	22,800	1,700	6,255.00
10	S	800 - 1,000	100	112	12 ft. 6 in.	25,700	1,850	7,470.00
15	S	1,200 - 1,500	150	160	12 ft. 6 in.	36,400	2,400	9,990.00
20	S	1,700 - 2,000	200	160	12 ft. 6 in.	53,100	2,400	11,655.00

Prices include: Plant complete with all pumps, condenser, steam trap, and all pipes and fittings to make the plant complete within itself.

Plants constructed entirely of ingot iron at an additional cost of 5 per cent.

Salt Filter.

Price on Standard Filter.....	\$200
Weight.....	800 lbs.
Diameter inside.....	2 ft. 6 in.
Length on the straight.....	2 ft. 4 in.
Cubic measurement for export.....	27 ft.



The Pick Evaporator.

A type of vacuum evaporator which has been employed in European practice, is illustrated and described under the name of Pick's triple effect evaporator, in Vol. 18 B of the International Library of Technology—Sect. 3, p. 8 (See Fig. 24). The following description is taken from that work:—

"In this apparatus is followed the principle of keeping each element under less pressure than in the preceding one, and evaporating its contents by means of steam taken from the preceding element. The brine enters at g, and at rs is a vertical coil of pipes, which, in the first element, is supplied with steam through e, and is sufficiently long to condense the steam so that it flows as water from the opposite end s. The heat from the steam coil evaporates the brine, ac, and the steam passes through the pipe f into a similar vertical coil at b', where it condenses and boils the brine in a'c', which stands under less pressure than in ac; the steam from a'c', in turn, evaporates the brine in a''c'', which is under still lower pressure. The salt as it separated collects in the funnels c, c', c'', and can be brought into the filter chambers, d, d', d'' when desired, by turning the valves at i, i', i''. Each filter chamber has a filter in the bottom portion from which a pipe h returns to the upper part of the element, so that the mother liquor may be returned if desired. The salt may then be washed by means of the rose x, and the wash water run off by the tap y. The salt can be withdrawn through an opening in the side of the filter chamber."

The Sanborn Evaporator.

The Sanborn evaporator is manufactured by the Sanborn Evaporator Company, New York city, N. Y., U. S. A. Fig. 25 shows the general assembly of a double effect evaporator of this type.

Construction.

The general construction of these evaporators is very similar to those already described, and consists of evaporating shell, heating element, cone shaped bottom, and salt filter.

The essential difference in this make of evaporator is in the heating element. The steam by which the brine is heated circulates inside the tubes, with the brine outside the same; instead of the brine within the tubes. The heating surface is composed of tubes 2" diameter outside, No. 16 Stubb's Wire Gauge, of seamless drawn copper (or other metal, as required), having their lower, or open end, rigidly expanded to the full

thickness ($2\frac{1}{2}$ ") of the main tube sheet. The upper end of each tube is seamlessly closed, and projects entirely free into the brine compartment of the evaporating chamber. The tubes, as usually supplied, have four feet of exposed tube above the upper face of the main tube sheet.

The inner tubes, whose function is the continuous removal of all air and non-condensable gases immediately upon their separation, are of $\frac{1}{2}$ " brass tube, iron pipe size, and extend to the extreme top of each heating tube. The lower extremity of each inner tube is connected to the secondary tube sheet by either a reverse brass bushing, or a special shaping of the tube itself.

The assembly of these inner tubes in the apparatus is extremely simple: the tube being entered from below, with the tube sheet in position, until the bushing or expanded portion of the tube reaches the counterbored lower face of the secondary tube sheet, and is then screwed solid with a brace carrying a screw-driver or socket wrench attachment. All the inner tubes open into a shallow compartment beneath the secondary tube sheet, and the eliminated air and gases are immediately delivered into the steam chamber of the next effect. The condensation formed on the heating surface is released as soon as formed, falling from the mouth of each open, vertical heating tube, on to the secondary tube sheet, from where it is withdrawn by suitable means.

The main tube consists of a cone shaped, cast iron sheet, $2\frac{1}{2}$ " thick; while the secondary tube sheet is of the same cone shape, but only $1\frac{1}{2}$ " thick, and is also made of cast iron.

The salt filter is furnished with a quick detachable strainer, which can be withdrawn in an instant, if necessary; although, in general operation, this strainer remains constantly in position.

Operation.

The steam is delivered into the steam chamber or calandria, which it completely and uniformly fills, and ascends, by the natural tendency of heat to rise, into the open end of each heating tube, equally. The natural circulation of the steam in a vertical direction, inside of each tube, is materially facilitated by the

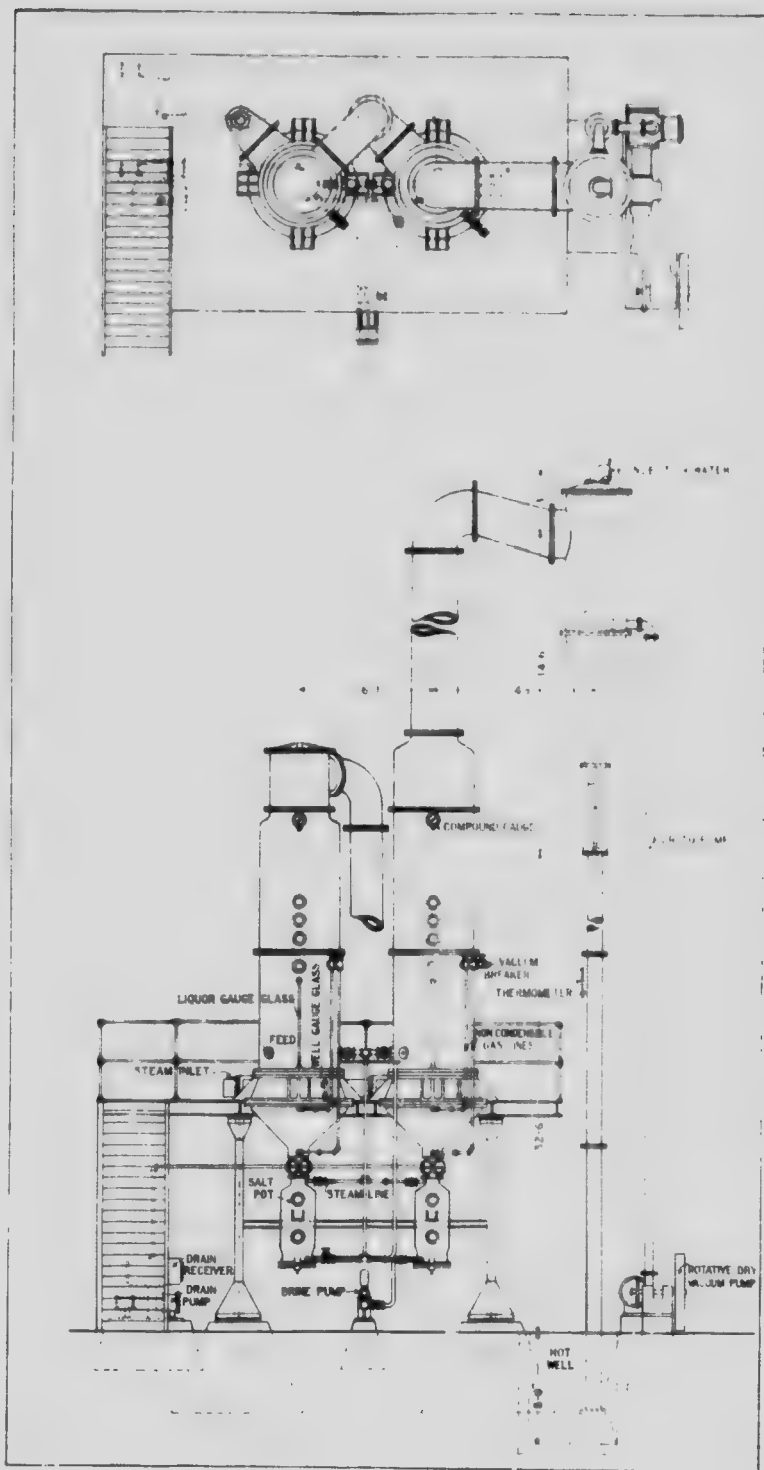


Fig. 25. General assembly, Sanborn double effect, evaporator, with salt filters.

immediate condensation in each tube, and further assisted by the upward current induced by the continuous withdrawal of the air and non-condensable gases from the highest points.

In this type of evaporator the brine is all outside of the heating tubes, and no downtake is used. The sharp-coned bottom permits the crystallized salt as formed—under the influence of its own weight and in the presence of the violent agitation of the boiling brine—to all drop to the lowest part of the cone, thence to fall directly into the salt filters, whence it is removed as needed.

PREPARATION OF SALT FOR THE MARKET.

All salt, whether manufactured in the vacuum or open pan, is generally allowed to age or season for at least two weeks before being shipped either in bulk or barrels. This seasoning gives time for the salt to become thoroughly drained and free from excess brine. The stock house in which the stock is stored is generally on the floor underneath the level on which the grainers are situated. The salt is then wheeled in carts along trestles over this stock house, and then dumped on the floor below.

The crude salt is shipped in bulk, being placed in cars or boat by any suitable means.

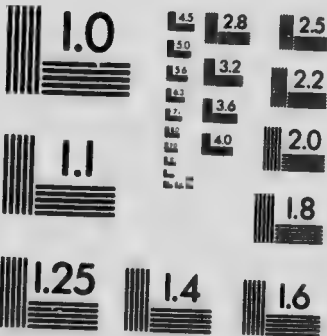
When packed in barrels the packing is carried on by hand on the floor of the stock house. Each barrel contains 280 pounds net. These barrels are generally manufactured on the premises.

In the case of table and dairy salt, a further treatment is carried on before the salt is placed on the market. The crude salt is passed through long, cylindrical, rotating driers, in which a current of hot air is blown through in the opposite direction to that in which the salt is moving, i.e., in a direction opposite to the incline of the drier. After being thoroughly dried, it is passed through a series of screens of various sizes, and then automatically bagged and sold as Dairy, Table, and Cheese salt. Each company has a special trade name under which it markets its product.



MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



APPLIED IMAGE inc

1653 East Main Street
Rochester, New York 14609 USA
(716) 482 - 0300 - Phone
(716) 288 - 5989 - Fax

SPECIAL USES OF SALT.

Besides the ordinary uses to which salt is put, such as domestic purposes, fish packing, meat curing, etc., there are several other uses which might be mentioned, such as its use in the metallurgical industry for a flux, and in certain chemical manufactories. As these uses are rather an important feature of the salt industry, they are dealt with briefly in a separate chapter.

CHAPTER X.

THE ALLIED INDUSTRIES.

Until recent years, the only use made of the extensive deposits of salt in Canada has been to produce commercial sodium chloride in the form of table, dairy, packing and other grades of salt. The rapid growth and commercial progress made by the Dominion during the last few years, however, has greatly accelerated the demand for industrial products. This demand has, in most cases, caused an increase in the importation of the material required. Among the materials—the demand for which has been most noticeable—are those chemicals produced by the industries that use sodium chloride, either directly or indirectly, as one of the principal raw materials. The increasing demand of the Canadian trade for these chemicals—as evidenced by the increase in imports as shown in Chapter VIII, page 96—has naturally evoked the question whether they cannot be manufactured in Canada. This question is partially answered by the fact that one company is already successfully producing caustic soda and bleaching powder from sodium chloride in the form of brine. But there are several other chemicals in the manufacture of which sodium chloride is utilized; and there is no reason why use should not be made of the extensive salt deposits of western Ontario in the establishment of these industries. In view of the rapidly increasing market there should be no difficulty in the disposal of the products of such undertakings.

In order that some idea may be obtained of their possibilities, a brief resume is here given of several of the more important processes for the manufacture of these chemicals.

SODIUM CARBONATE.

Soda Ash.

Although sodium carbonate is often found in extensive deposits in nature, it is generally very impure. Owing to the cost of dissolving, evaporating, and purifying, it rarely pays

to operate a deposit of this nature, except at actual points of consumption, as commercial sodium carbonate can more readily be prepared artificially from sodium chloride.

In the artificial preparation of sodium carbonate there are two processes of importance which use sodium chloride as a raw material.¹ These two processes are (1) the Solvay, or ammonia-soda process, and (2) the electrolytic process.

(1) The Solvay Process.

The re-action of ammonium bicarbonate on sodium chloride, with the separation of part of the sodium as sodium bicarbonate, was known to the chemists during the early part of the nineteenth century. A number of patents have been taken out in many countries, based on this re-action, and attempts were made to commercialize the different processes, with only indifferent success. About 1861, Ernest Solvay, a Belgian, commenced work along this line, and after a number of years of experimenting succeeded in overcoming the mechanical difficulties, and placed the process on a commercial basis. His inventions, although in a greatly modified form, are now employed in the process as carried on under his name in many of the large soda works, both in Europe and America.

The re-action upon which his process is based may be stated in the following equation:—



The raw materials required for this process are limestone, sodium chloride (either as brine as it comes from the wells or rock salt dissolved), ammonia (either in the form of an ammonium hydrate solution or ammonium sulphate), and fuel.

In brief, the essential operations in this process are, to manufacture carbon dioxide from limestone; to pass this gas into the ammoniacal brine, which has previously been prepared by saturating the brine with ammonia gas; the separation of sodium bicarbonate which forms as a precipitate from the

¹The Le Blanc process for the manufacture of soda uses sodium chloride indirectly, inasmuch as the sodium sulphate used in this process is produced from salt. As the process of producing sodium sulphate from salt is described later, no further mention is made of the Le Blanc process.

solution; and the calcining of this precipitate to form sodium carbonate, or soda ash. The carbon dioxide formed from the calcining of the bicarbonate is employed again, as is also the ammonia, which is recovered from the solution—where it is in the form of ammonium chloride. The re-actions which take place may be stated by the following equations:—

Limestone is burned to form CO_2 .



The CO_2 is passed into the ammoniacal brine, where it re-acts with the ammonia to form ammonium bicarbonate, which immediately re-acts with the sodium chloride to form sodium bicarbonate.

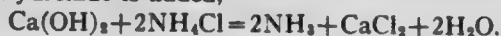


The sodium bicarbonate is calcined to produce soda ash.



The carbon dioxide thus recovered is again used in the process.

To recover the ammonia from the ammonium chloride calcium hydroxide is added,



The calcium chloride thus produced is generally run to waste.

When considering the erection of an ammonia-soda factory, it is well to locate where the salt is cheap and where sufficient quantities of pure limestone can be obtained.

(2) Electrolytic Process for Preparation of Soda Ash.

An electrolytic process for the manufacture of sodium carbonate crystals from the electrolysis of brine has been perfected and operated commercially, on a small scale, in England. This process known as the "Hargreave and Bird process," consists of a diaphragm cell in which the walls of the cell are the diaphragm and the cathode. The diaphragm is impervious to the salt solution, but permits the sodium ion to pass. As the sodium ions are set free, they are converted into soda crystals by the blowing in of steam and carbon dioxide.

Sodium carbonate, or soda ash, is used for many different purposes, the principal ones being, in the manufacture of glass; in the making of certain kinds of soap; and in the purification of oils, etc.

SODIUM SULPHATE.

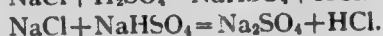
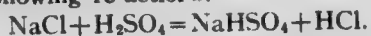
(*Salt Cake.*)

Like sodium carbonate, sodium sulphate occurs naturally, in large deposits, in the United States and other countries. The artificially manufactured substance, however, is so cheap that it seldom pays to use these natural deposits.

Artificial sodium sulphate is generally known as salt cake, and the commonest process for producing it is from the action of sulphuric acid on sodium chloride. The salt for this process is preferably rock salt or the coarsest salt produced from evaporation.

The process may be carried on in two ways (1) sulphuric acid as such, may be added, directly to the sodium chloride, or (2) sulphur dioxide, oxygen, and steam may be added to the sodium chloride.

By the first method, the acid sodium sulphate is formed, and this re-acts again with salt to form sodium sulphate according to the following re-action:—



This process is the one which has, until recent years, been most employed in the manufacture of salt cake.

The second method, known as the Hargreave process, has found favour lately in England and Europe, and large quantities are now being made by this method. The re-action may be stated as follows:—



Sodium sulphate finds its principal use as one of the raw materials in the manufacture of sodium carbonate by the Le Blanc process. It finds a smaller use in the manufacture of glass, and for certain dyes. When crystallized, it is used medicinally under the name of Glaubers salts.

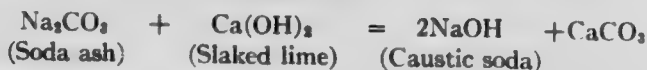
HYDROCHLORIC ACID.

The production of hydrochloric acid from sodium chloride is accomplished during the process just described for the making of salt cakes. The acid escaping from the pans or roasters of the salt cake manufacture is condensed in suitable condensing apparatus. Many types of condensing apparatus are employed, all more or less satisfactory.

SODIUM HYDRATE.

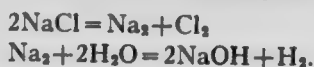
(*Caustic Soda*).

Until the last 50 years, the manufacture of caustic soda was not extensive. The most common process in preparing caustic soda was the one in which advantage was taken of the re-action of sodium carbonate and slaked lime. The re-action is expressed by the following equation:—



This process at first entailed the production of soda ash. Of late years, however, caustic soda has been prepared by the direct decomposition of sodium chloride in an electrolytic cell; producing chlorine gas and metallic sodium, which latter at once unites with water to form caustic soda. The caustic thus produced is weak, owing to its dilution with the water present in the cells, and this requires that it be concentrated.

The re-action which takes place in the cell is:—



There are two methods employed in the electrolytic production of caustic soda. The first one is that in which a fused electrolyte is employed, while the second process makes use of a solution of salt in water, as the electrolyte.

The first process presents great difficulty, as there is the question of keeping the electrolyte fused; but the caustic so produced requires very little fuel for evaporation. There are, however, several processes involving the use of the fused electrolyte, which are being operated successfully.

The wet process, or the one in which sodium chloride in solution is used as the electrolyte, is the most extensively employed on this continent. The great difficulty with this method is that, unless these materials are at once passed into an inactive region, the tendency of the materials formed at the electrodes is to reunite and form compounds that are objectionable, and which interfere with the electrolytic action.

Several methods are employed to keep the products of the electrodes separate. The most important of these are: (1) by diaphragms, (2) by density difference, and (3) by mercury cathode.

Diaphragm Cell.

In the cell of this type the liquor around the anode is completely separated from that around the cathode by means of a diaphragm. This diaphragm must be composed of some material that will resist the action of the solutions in the cell, and at the same time not offer any great resistance to the passage of the current. This is the type of cell employed by the Canadian Salt Company at their chemical branch, Sandwich, Ont.

Difference in Density of Original Solution and Products.

By this method the difference in the specific gravity of the original solution and the product formed at the electrodes is taken advantage of. The process, as applied to the production of caustic soda and chlorine, consists in placing the cathode in the bottom of the cell with the anode at the top. This arrangement allows the chlorine to be liberated without having much of the solution to traverse, and the caustic soda, being heavier than the salt solution, remains in the bottom of the cell, and is drawn off from time to time.

Mercury Cathode.

In this method a mercury cathode is employed. The sodium is separated from the chlorine in the cell in the form of amalgam with the mercury, and can be removed and afterwards

converted into the hydrate form. This method causes little wear and tear on the cells; but it requires a large quantity of mercury to be constantly in use for each ton of caustic produced.

Chlorine.

In the process just described for the manufacture of sodium hydroxide by the electrolysis of salt, chlorine is produced as one of the products of decomposition. This chlorine may be utilized in several different ways; but its principal use is in the preparation of bleaching powder by passing the gas over slaked lime.

Bleaching Powder.

When dry chlorine gas is passed over a thin layer of slaked lime, a compound is formed which has the power to readily give up its chlorine, when acted upon by an acid.

In brief, the process generally employed consists of passing the chlorine gas through a series of large leaden-lined chambers, in which slaked lime is spread on the floor to a depth of about two inches. The floor is made of cement and asphalt, in which are buried the pipes for the cooling process. The prepared bleach is drawn from the chambers by means of openings in the floors. Generally, a number of these chambers are operated in series, thus doing away with the necessity of stirring the lime, and the consequent escape of chlorine gas during the turning operation.

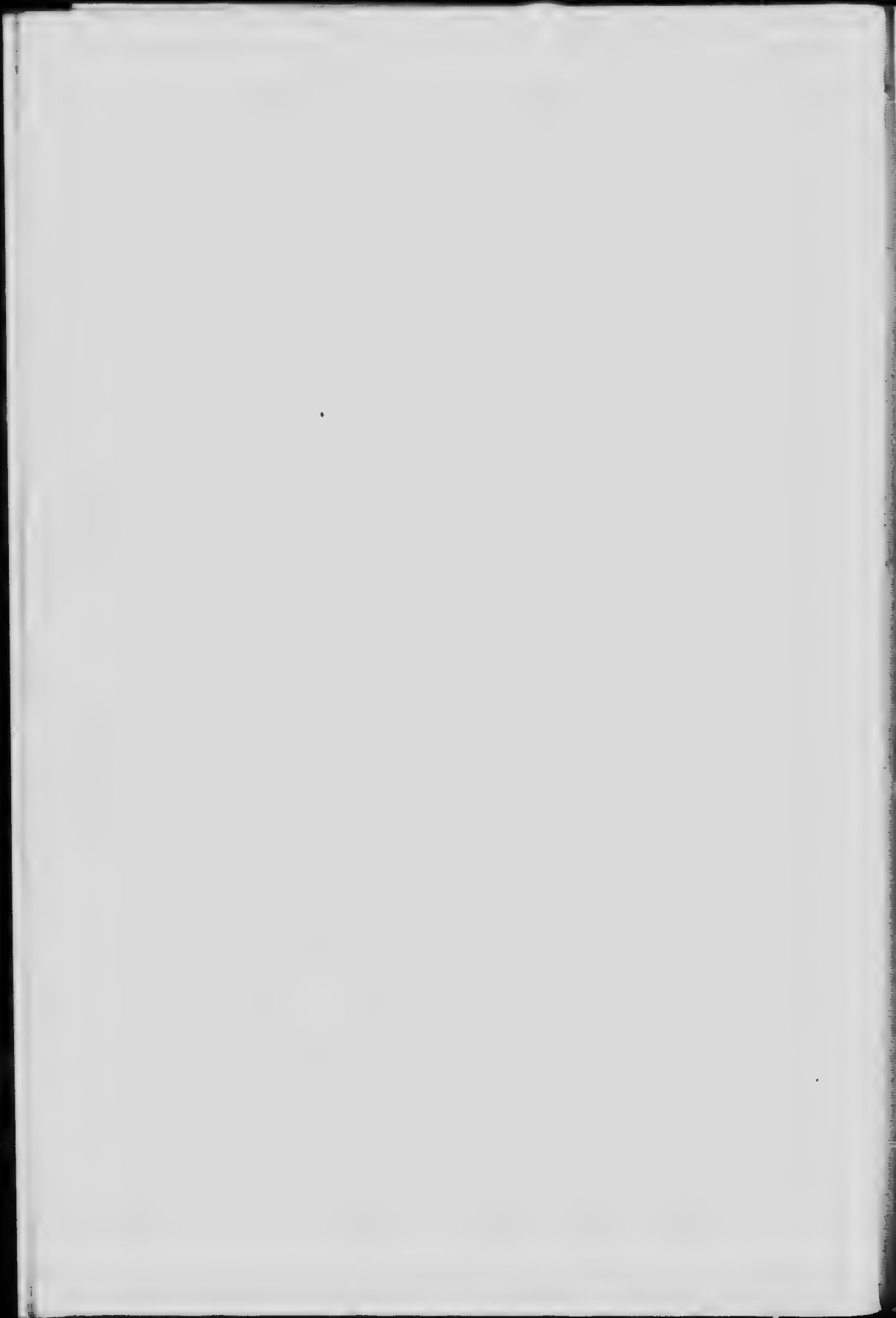
Bleaching powder or chloride of lime, is used extensively in the bleaching of vegetable fibres, and also as a disinfectant.



APPENDICES

Bibliography

- APPENDIX I. CANADA AND UNITED STATES: ARRANGED ACCORDING TO PROVINCES AND STATES.
- " II. WORLD-WIDE REFERENCES.
- " III. AUTHORS: ARRANGED ALPHABETICALLY.



BIBLIOGRAPHY.

APPENDIX I.

CANADA AND UNITED STATES:
ARRANGED ACCORDING TO PROVINCES AND STATES.

CANADA.

Geological Survey, General Index, 1885-1906.

Geological Survey of Canada, 1885-1906, pp. 818-820.

Geological Survey of Canada, 1863-1884, pp. 392-393.

Ingalls, E. D., Rep. Geol. Surv. of Canada, Vol. I, (N.S.) 1886, Pt. 5, on salt.

Smith, J. S., History and Statistics of the Trade and Manufacture of Canadian Salt, Geol. Surv. of Canada, Rep. of Progress, 1874-75.

New Brunswick.

Bailey, L. W., The Mineral Resources of the Province of New Brunswick, Rep. Geol. Surv. of Canada, Vol. X, 1897, Pt. M.

Ontario.

Bureau of Mines, General Index, 1891-1907, p. 363.

Brummell, H. P. H., Rept. on the Natural Gas and Petroleum in Ontario, Rep. Geol. Surv. of Canada, Vol. V, 1890-91, Pt. Q.

Hunt, T. S., Geology of Petroleum and Salt, Geol. Surv. of Canada, Rep. of Progress, 1865-66.

Hunt, T. S., On the Goderich Salt Region, Geol. Surv. of Canada, Rep. of Progress, 1866-69.

Hunt, T. S., The Goderich Salt Region, Geol. Surv. of Canada, Rep. of Progress, 1876-77.

Hunt, T. S., On the Goderich Salt Region, Trans. Am. Inst. Mining Engineers, Vol. V.

Nova Scotia.

Fletcher, Hugh, on the Geological Surveys and Explorations in counties of Guysborough, Antigonish, Pictou, Colchester and Halifax, Nova Scotia; Rep. Geol. Survey of Canada, 1886, Pt. P.

Saskatchewan.

McConnell, R. G., On the Cypress Hills, Wood Mountain and Adjacent Country; Rep. of Geol. Surv. of Canada, 1885, Pt. C. pp. 15 and 22.

Manitoba.

Hoffman, G. C., Analyses of Brines from Manitoba; Rep. Geol. Surv. of Canada, Vol. V, 1890-1891.

United States.

Trans. American Institute Mining Engineers; Vol. 36-40, 1905-1909, p. 134.

Trans. American Institute Mining Engineers; Vols. 1-35, 1871-1904.

Virginia.

Eckel, E. C., Salt and Gypsum Deposits of South Western Virginia; Bull. U. S. Geol. Surv., No. 213, 1903, pp. 406-416.

Stose, G. W., Geology of the Salt and Gypsum deposits of Southwestern Virginia; Bull. U. S. Geol. Surv. No. 530, 1912.

Utah.

Barboer, P. E., The Utah Solar Salt Industry; Eng. & Min. Journ., July 8th, 1911, pp. 444-449.

Eckel, E. C., The Salt Industry in Utah and California; Bull. U. S. Geol. Surv., No. 225, 1904, pp. 488-495.

West Virginia.

Grimsby, G. P., Salt in West Virginia; West Virginia Geol. Surv., Vol. IV, Pt. 2, 1909, pp. 286-354.

Texas.

Cummins, W. F., Salt in Northwestern Texas; Second Annual Report Texas Geol. Surv., 1891, pp. 444-449.

Richardson, G. B., Salt Gypsum of Petroleum in Trans-Texas; Bull. U. S. Geol. Surv. No. 260, 1905, pp. 573-585.

Ohio.

Bownocker, J. A., Salt Deposits and the Salt Industry in Ohio; Bull. Ohio Geol. Surv., No. 8, Vol. 9, 1906.

Root, W. J., The Manufacture of Salt Bromine; Report Ohio Geol. Surv., Vol. VI, 1888, pp. 653-670.

Oklahoma.

Gould, C. N., The Oklahoma Salt Plains; Trans. Kansas Acad. Sci., Vol. 17, 1899-1900, pp. 181-184.

Snider, L. C., The Gypsum and Salt of Oklahoma; Bull. II, Oklahoma Geol. Surv., July 1913.

Gould, C. N., Salt; Bull. Oklahoma Geol. Surv., No. 6, 1910, p. 71.

New Mexico.

- Darton, N. H., Zune Salt Deposits, New Mexico; Bull. U. S. Geol. Surv., No. 260, 1905, pp. 565-566.

Louisiana.

- Harris, G. D., Rock Salt: Its origin, geological occurrences, and economic importance in State of Louisiana; Bull. Louisiana Geol. Surv. No. 7, 1908, pp. 259.
- Harris, G. D., The Geological Occurrence of Rock Salt in Louisiana and East Texas; Economic Geol. Vol. IV, No. 1, 1909, pp. 12-34.
- Hilgard, E. W., The Salines of Louisiana; Mineral Resources U. S. for 1882, 1883, pp. 554-565.
- Lucas, A. F., Rock Salt in Louisiana; Trans. Am. Inst. Min. Eng., Vol. 29, 1899, pp. 462-474.
- Lucas, A. F., The Avery Island Salt Mines and the Joseph Jepherson Salt Deposit; Eng. & Min. Journ., Nov. 14, 1896.
- Phenis, Albert, Louisiana's Island Salt Mines; Manufacturers Record, June 22nd, 1911, p. 48.
- Veatch, A. C., The Five Islands; Report Louisiana Geol. Surv. for 1899, Special Report No. 3, pp. 213-262.
- Veatch, A. C., The Salines of North Louisiana; Report Louisiana Geol. Surv. for 1902, pp. 47-100.
- Wooten, Paul, Louisiana Salt Mines: Their operation and output; Min. and Eng. World, Feb. 17, 1912, pp. 401-402.

Iowa.

- Wilder, F. A., The Age and Origin of the Gypsum of Central Iowa; Jour. Geol., Vol. II, 1903, pp. 723-748.

Michigan.

- Lane, A. C., Geol. Surv. of Michigan, Rep. for year 1901-1902, pp. 241-242.
- Hubbard, L. L., The Origin of Salt, Gypsum and Petroleum, Geol. Surv. Michigan, Pt. 2, 1895, pp. 9-24.
- Cook, C. W., Brine and Salt Deposits of Michigan; Pub. 15, Geol. series 12, Michigan Geol. Surv.

New York.

- Englehardt, F. E., The Manufacture of Salt in the State of New York; Bull. N. Y. State Museum, No. 11, 1893, pp. 38-69.
- Kindle, E. M., Salt Resources of the Watkins Glen district, N. Y.; Bull. U. S. Geol. Surv., No. 260, 1905, pp. 567-572.

Merril, F. J. H., Salt and Gypsum Industries of New York, Bulletin of the New York State Museum, Vol. III, No. 11, 1893, pp. 1-38.

Newland, D. H., The Mining and Quarry Industry of New York State; Bulletin of New York State Museum, No. 161, p. 55.

California.

Bailey, Gilbert, The Saline Deposits of California; Bull. California State Mining Bureau, No. 24, 1902, pp. 105-138.

Dolbeur, C. E., The Searles Lake Potash Deposit; Eng. & Min. Journ., Feb. 1st, 1913, p. 259.

Eckel, E. C., The Salt Industry of Utah and California; Bull. U. S. Geol. Surv., No. 225, pp. 488-495.

Idaho.

Breger, C. L., The Salt Resources of the Idaho-Wyoming Border, with Notes on the Geology; Bull. U. S. Geol. Surv., No. 430, 1910, pp. 555-569.

Wyoming.

Schultz, A. R., Deposits of Sodium Salts in Wyoming Reservation of the United States; 1200 w. Min.-Wld., Dec. 31, 1910.

Wyoming.

Breger, C. L., The Salt Resources of the Idaho-Wyoming Border, with Notes on the Geology; Bull. U. S. Geol. Surv., No. 430, 1910, pp. 555-569.

Kansas.

Ainsworth, Samuel, The Rock Salt Mining Industry in Kansas; Eng. and Min. Journ., Sept. 4, 1909, pp. 454-456.

Kirk, M. Z., Kansas Salt; Mineral Resources of Kansas 1898, pp. 66-97, Technology of Salt: pp. 98-123.

Young, C. M., Notes on the Evaporated Salt Industry of Kansas; Eng. and Mining Journ., Sept. 18, 1909, pp. 558-561.

Young, C. M., Rock Salt Mining Operations in Central Kansas; Mining World, June 17, 1911, pp. 1223-1225.

APPENDIX II.

WORLD-WIDE REFERENCES.

Salt-Mining and Geology.

Davies, D. C., A Treatise on Earthy and other Minerals and Mining; Chap. IV and V, pp. 61-101.
The Cheshire Salt Industry; Chemical Trade Journal, Sept. 30th, 1911.

- Fliegel, G., Zethstein Salt in the lower bottom on Rhine, Gluckauf, Jan. 20, 1912.
- Frasch, H., An Improved Method for Mining Salt; Min. World, Feb. 15, 1908.
- Hahn, F. F., The Form of Salt Deposits; Econ. Geology, Vol. 7, No. 2, Feb.-Mar. 1912, pp. 120-125.
- Kegel, H., Underground Workings in Potash Salt Mines of great depth; Gluckauf, Oct. 6, 1906.
- Niedzwiedz, I. J., Geological Sketch of the Salt Mountains of Kalusz in East Galicia in Ostgalizien; Sereal 1st Pt. July 27, 1912.
- Piestrak, F., The Salt Pits in Galicia and Bukowina; Oest Zeitschr f Berg-u-Huttenwesen, Feb. 17, 1910.
- Reinl, H., The Grubach and Abtenau Salt Deposits; Oest Zeitschr f Berg-u-Huttenwesen, April 16, 1910.
- Germany's Salt Productions in Year 1906; Statistical Review, Pt. 1, Oest Zeitschr f Berg-u-Huttenwesen, Feb. 3rd, 1912.
- Schnable, A., Statistics of the Alpine Salt Industry; Oest Zeitschr f Berg-u-Huttenwesen, May 14th, 1910.
- Schraml, C., Leaching Brine from Salt Mines; Oest Zeitschr f Berg-u-Huttenwesen, April 23, 1910.
- Schry, C., The Artificial Lixiviation of Rock Salt; Serial Pt No. 2 Oest Zeitschr f Berg-u-Huttenwesen, Oct. 27, Nov. 3, 1906.
- Thompson, F. J., Salt Mining Near Fleetwood; Col. Guard, May 24, 1907.
- Wunstorff, W., Zethstein Salt in the lower Rhine Bottoms; Gluckauf, Jan. 20, 1912.
- Lomas, John, Alkali Trade, A Manual, 2nd Edition, p. 376.
- Buschmann, J., Ottaker von-Das Salz, dessen Vorkommen und Verwertung in Samtlichen staaen der Erde, Leipzer, 1909, Vol. I, p. 768, Vol. II, p. 506.
- Merrill, G. P., The Non-metallic Minerals, pp. 43-63, 2nd Edition revised.
- Technology of Salt.**
- Schrempf, J., The Kayser Process for the Production of Table Salt and the Concentration or Evaporation of other Solutions; Gluckauf, Feb. 3, 1912.
- Scientific American Supplement, Salt Manufactured in Great Britain, Feb. 3, 1912.
- Ochsenius, C., Bildung von Steinsalzlageren; Chem. Zeitung, Vol. II, 1887, pp. 848, 935, 962 and 1549.

Hayward, A. A., Salt: Its history and manufactures, also occurrence; March 1906, pp. 99-116, Vol. II.

Chatard, T. M., The Salt making processes in the United States; 70th Ann. Rept. U. S. Surv., 1888, pp. 120-125.

New Salt Works in Cheshire; Lond. (Engineer), June 10th, 1910, and Oct. 27th, 1911.

Ward, F., Manufacture of Salt; Journ. Coc. Arts., 1894.

APPENDIX III.

AUTHORS.

Ainsworth, Samuel.

Kansas. The Rock Salt Mining Industry in Kansas; Eng. and Min. Journ., Sept. 4, 1909, pp. 454-456.

Bailey, Gilbert.

California. The Saline Deposits of California; Bull. California State Mining Bureau, No. 24, 1902, pp. 105-138.

Bailey, L. W.

New Brunswick. The Mineral Resources of the Province of New Brunswick; Rep. Geol. Surv. Can., Vol. X, 1897, Pt. M.

Barbour, P. E.

Utah. The Utah Solar Salt Industry; Eng. and Min. Journ., July 8, 1911, pp. 74-75.

Bownocker, J. A.,

Ohio. Salt Deposits and the Salt Industry in Ohio; Bull. Ohio Geol. Surv., No. 8, Vol. 9, 1906.

Breger, C. L.

Idaho, Wyoming. The Salt Resources of the Idaho-Wyoming Border, with Notes on the Geology; Bull. U. S. Geol. Surv., No. 430, 1910, pp. 555-569.

Brumell, H. P. H.

Ontario. Report on the Natural Gas and Petroleum in Ontario; Rep. Geol. Surv. of Canada, Vol. V, 1890-91, Pt. Q.

Buschmann, J. Ottaker von,

Das Salz, dessen Vorkommen und Verwertung in Samtlichen staaen der Erde, Leipzig, 1909, Vol. I, p. 768, Vol. II, p. 506.

Chatard, T. M.

The Salt Making Processes in the United States; 7th Ann. Rep. U. S. Surv., 1888, pp. 120-125.

Chemical Trade Journal

The Cheshire Salt Industry; Sept. 30, 1911.

Cummins, W. F.

Texas. Salt in North Western Texas; 2nd Ann. Rept., Texas Geol. Surv., 1891, pp. 444-449.

Darton, N. H.

New Mexico. Zune Salt Deposits, New Mexico; Bull. U. S. Geol. Surv., No. 260, 1905, pp. 565-566.

Davies, D. C.

A Treatise on Earthy Minerals and Mining; Chaps. IV, V, pp. 61-101.

Dolbear, C. E.

California. The Searles Lake Potash Deposit; Eng. and Min. Journ., Feb. 1st, 1913, p. 259.

Eckel, E. C.

California, Utah. The Salt Industry in Utah and California; Bull. U. S. Geol. Surv., No. 225, 1904, pp. 488-495.

Virginia. Salt and Gypsum Deposits of Southwestern Virginia; Bull. U. S. Geol. Surv., No. 213, 1903, pp. 406-416.

Englehardt, F. E.

New York. The Manufacture of Salt in the State of New York; Bull. N. Y. State Museum, No. 11, 1893, pp. 38-69.

Fletcher, Hugh,

Nova Scotia. On Geological Surveys and Explorations in Counties of Guysborough, Antigonish, Pictou, Colchester, and Halifax, Nova Scotia; Rept. Geol. Surv., Canada, 1886, Pt. P.

Fliegel, G.

Zethstein Salt in the lower bottom on Rhine; Gluckauf, Jan. 20, 19

Frasch, Hermann.

An Improved Method for Mining Salt; Min. World, Feb. 15, 1908.

Grimsby, G. P.

West Virginia. Salt in West Virginia; West Virginia Geol. Surv., Vol. IV, Pt. 2, 1909, pp. 286-354.

Gould, C. N.

Oklahoma. The Oklahoma Salt Plains; Trans. Kansas Acad. Sci., Vol. XVII, 1899-1900, pp. 181-184.

Oklahoma. Salt. Bull. Oklahoma Geol. Surv., No. 6, 1910, p. 71.

Hahn, F. F.

The Form of Salt Deposits; Econ. Geol., Vol. VII, No. 2, Feb. Mar., 1912, pp. 120-125.

Harris, G. D.

Louisiana. Rock Salt: Its Origin, Geological Occurrences, and Economic Importance in the State of Louisiana; Bull. Louisiana Geol. Surv., No. 7, 1908, pp. 259.

Louisiana. The Geological Occurrences of Rock Salt in Louisiana and East Texas; Econ. Geol., Vol. IV, No. 1, 1909, pp. 12-34.

Haywood, A. A.

Salt: Its History and Manufactures and Occurrence; March, 1906, pp. 99-116, Vol. II.

Hilgard, E. W.

Louisiana. The Salines of Louisiana; Mineral Resources U. S. for 1882-1883, pp. 554-565.

Hoffman, G. C.

Manitoba. Analyses of brines from Manitoba; Rep. Geol. Surv. of Canada, Vol. V, 1890-91.

How, Dr. Henry,

Nova Scotia. On some Brine Springs of Nova Scotia; Proc. and Trans. of the N. S. Inst. of Nat. Sci., Vol. I, Pt. 3, p. 75.

Hubbard, L. L.

Michigan. The Origin of Salt, Gypsum, and Petroleum; Geol. Surv. Mich., Pt. 2, 1895, pp. 9-24.

Hunt, T. S.

Ontario. Geology of Petroleum and Salt; Geol. Surv. of Canada, Rep. of Prog., 1865-66.

Ontario. On the Goderich Salt Region; Geol. Surv. of Canada, Rep. of Progress, 1866-69.

- Ontario. The Goderich Salt Region; Geol. Surv. of Canada, Rep. of Progress, 1876-77.
- Ontario. On the Goderich Salt Region; Trans. Am. Inst. Mining Engineers, Vol. V.
- Ingall, E. D.**
Canada. On Salt; Rep. Geol. Surv. Canada, Vol. I, N. S., 1886, Pt. S.
- Kegel, H.**
Underground Working in Potash Salt Mines of Great Depth; Gluckauf, Oct. 6, 1906.
- Kindle, E. M.**
New York. Salt Resources of the Watkins Glen District, N. Y.; Bull. U. S. Geol. Surv., No. 260, 1905, pp. 567-572.
- Kirk, M. Z.**
Kansas. Kansas Salt; Mineral Resources of Kansas, 1898, pp. 66-97.
Kansas. Technology of Salt; Mineral Resources of Kansas, 1898, pp. 98-123.
- Lane, A. C.**
Michigan. Report for year 1901; Geol. Surv. of Michigan.
- Lomas, John.**
Alkali trade, A Manual, 2nd Ed., p. 376.
- London Engineer.**
New Salt Works in Cheshire, June 10, 1910.
New Salt Works in Cheshire, Oct. 27, 1911.
- Lucas, A. F.**
Louisiana. Rock Salt in Louisiana; Trans. Am. Inst. Min. Eng., Vol. XIX, 1899, pp. 462-474.
Louisiana. The Avery Island Salt Mines and the Joseph Jepherson Salt Deposits; Eng. and Mining Journ., Nov. 14, 1911.
- McConnell, R. G.**
Saskatchewan. On the Cypress Hills Wood Mountain and Adjacent Country; Rep. Geol. Surv. of Canada, 1885, Pt. C, pp. 15-22.
- Merrill, F. J. H.**
New York. Salt and Gypsum Industries of New York, Bull. N. Y. State Museum, Vol. III, No. 11.

Merrill, G. P.

The Non-metallic Minerals, 2nd Ed. revised.

Newland, D. H.

New York. The Mining and Quarry Industry of New York State; N. Y. State Museum, Bull. No. 161, p. 55.

Niedzwiedski, J.

Geological Sketch of the Salt Mountains of Kalusz in East Galicia in Ostgalizien; Serial 1st pt., July 27, 1912.

Ochsenius, C.

Bildung von Steinsalzlageren; Chem. Zeitung, Vol. II, 1887, pp. 848, 935, 962, 1549.

Phenis, Albert,

Louisiana. Louisiana's Island Salt Mines; Manufacturers Record, June 22nd, 1911, p. 48.

Piestrak, Felix,

The Salt Pits in Galicia and Bukowina, Oest Zeitschr f Berg-u-Huttenwesen, Feb. 17, 1910.

Reinl, Hans,

The Grubach and Abtenau Salt Deposits, Oest Zeitschr f Berg-u-Huttenwesen, Apr. 16, 1910.

Richardson, G. B.

Texas. Salt, Gypsum and Petroleum in Trans-pecos Texas; Bull. U. S. Geol. Surv., No. 260, 1905, pp. 573-585.

Root, W. J.

New York. The Manufacture of Salt and Bromine; Rep. Ohio Geol. Surv., Vol. VI, 1888, pp. 653-670.

Schnable, Anton,

Statistics of the Alpine Salt Industry; Oest Zeitschr f Berg-u-Huttenwesen, May 14, 1910.

Schraml, C.

Leaching Brine from Salt Mines; Oest Zeitschr f Berg-u-Huttenwesen, April 23, 1910.

The Artificial Lixiviation of Rock Salt; Oest Zeitschr f Berg-u-Huttenwesen, Oct. 27, Nov. 3, 1906.

Schrempf, J.

The Kayser Process for the Production of Table Salt and the Concentration or Evaporation of other Solutions; Gluckauf, Feb. 3, 1912.

Schult, A. R.

Wyoming. Deposits of Sodium Salts in Wyoming; Min. World, Dec. 31, 1910, No. 19858.

Salder, L. C.

Oklahoma. The Gypsum and Salt of Oklahoma; Bull. 11, Oklahoma, Geol. Surv., July 1913.

Smith, J. S.

Canada. History and Statistics of the Trade and Manufacture of Canadian Salt; Geo. Surv. of Canada, Rept. of Progress, 1874-75.

Statistical Review.

Germany's salt production in year 1906-10, 2 parts, Oest Zeitschr f Berg-u-Huttenwesen, Feb. 3, 1912.

Stose, G. W.

Virginia. Geology of the Salt and Gypsum Deposits of Southwestern Virginia; Bull. U. S. Geol. Surv. No. 530, 1912.

Scientific American Supplement

Salt Manufacture in Great Britain; Feb. 3, 1912.

Thompson, Fred. J.

Salt Mining near Fleetwood; Col. Guard, May 24, 1907, No. 84756, A.

Veatch, A. C.

Louisiana. The Five Islands; Report Louisiana Geol. Surv. for 1899, Special report No. 3, pp. 213-262.

Louisiana. The Salines of North Louisiana, Rept. Louisiana Geol. Surv. for 1902, pp. 47-100.

Ward, F.

Manufacture of Salt; Jour. Coc. Arts, 1894.

Wilder, F. A.

Iowa. The Age and Origin of the Gypsum of Central Iowa; Jour. Geol., Vol. II, 1903, pp. 723-748.

Wooten, Paul,

Louisiana. Louisiana Salt Mines: Their Operation and Output; Mining and Engineering World, Feb. 17, 1912, pp. 401-402.

Wunstorff, W.

Zethstein Salt in the Lower Rhine Bottoms, Jan. 20, 1912.

Young, C. M.

Kansas. Notes on the Evaporated Salt Industry of Kansas; Eng. and Min. Journ., Sept. 18, 1909, pp. 558-561.

Kansas. Rock Salt Mining Operations in Central Kansas; Min. World, June 17, 1911, pp. 1223-1225.

INDEX

A		PAGE
Acknowledgments.....		2
Admiralty island salt spring.....		92
Alberta salt: occurrence in.....		83
Allied industries.....		131
Analysis: Admiralty island salt spring.....		42
" eight samples brines.....		47
" Goderich well.....		31
" government well, Neepawa.....		76
" Manitoba brines.....		53
" material from mound Salt Spring C.....		65
" mineral water at Elmwood.....		78
" Nanaimo salt spring.....		92
" Pelican bay brine.....		56
" Red Earth saline spring.....		88
" Saline spring A, brine.....		61
" " B.....		62
" " B, till under.....		63
" " C, brine.....		64
" " C, gas.....		64
" " D, brine.....		66
" " E.....		67
" " F.....		68
" " G.....		69
" " H.....		70
" " I.....		71
" " J.....		72
" " (well) K, brine.....		73
" " L.....		74
" " M.....		75
" Salt point brine.....		57
" Salts, La Saline.....		86
" spring at Salt Springs.....		18
" springs at Salina.....		19
" Steeprock river brine.....		58
" Swan river brine.....		59
" water, La Saline.....		86
" Well K.....		73
" L.....		74
" Whycocomagh brine.....		16
Antigonish: saline springs at.....		17
Appendices: See Bibliography.....		
Artificial heat evaporation.....		114
Athabaska Oils, Ltd.—saline water struck by.....		85
Attrill, Henry: test boring at Goderich.....		22
B		
Bailey, Dr. L. W.—quoted re salt springs near Sussex.....		19
Bar theory of origin of salt.....	10,	29
Barometric leg.....		119
Bay salt: explanation of term.....		113

II

	PAGE
Bibliography: Canada and United States.....	141
" World wide references.....	144
" Authors.....	146
Bischof: propounder of Bar theory origin of salt.....	10
Bittern lake: visited by author.....	90
Bleaching powder: manufacture and use of.....	137
Bonaparte valley, B.C.—saline springs.....	92
Brecht salting evaporator.....	124
Brine springs one of chief sources for salt.....	103
Brines: artificial.....	104
" common in nearly all countries.....	4
" concentration of.....	105
" method of pumping.....	105
" natural, two classes.....	103
British Columbia, salt in.....	91
" Salt Works, Ltd.....	92
Bromine.....	56
" in Manitoba brines.....	79

C

Camsell, Chas.—Notes on saline springs of Salt river.....	87
Canadian Alkali Co., Sandwich: contemplated operations of.....	47
" Salt Co., Sandwich.....	100
" chemical branch, Sandwich: description.....	41
" only co. producing chemical products from sodium chloride.....	41
" Sandwich: description of salt plant.....	46
" Windnor.....	100
" description of plant.....	40
" Salt Works: log of well No. 4.....	26
" 	7
Carnallite.....	64
Carter, Dr. F. E.—analysis of gas from salt spring.....	100
Carter and Kiddermaster, Sarnia salt works.....	
Caustic soda: See Sodium hydrate.....	19
Chambers, R.—brine at Sussex sampled by.....	18
Cheverie, N. S.—brines found at.....	92
Chilcotin valley, B.C.—saline lakes.....	137
Chlorine: production and use.....	90
Christina river: salt springs.....	32
Clinton: works erected at.....	119
Cone-shaped bottom pan.....	12
Cook, Dr. Chas. W.—Walther's theory summarized.....	29
Cook: opinion of origin of salt in Salina formation.....	90
Cypress hills: saline lakes.....	

D

Dawson, G. M.—saline lakes in Chilcotin valley, B.C.....	92
" springs, Maiden creek, B.C.....	92
Deacon, Josiah: salt operations at Antigonish.....	17
Dead sea, Palestine: source for production of salt.....	103
Dominion salt block, Goderich.....	32
" Salt Co.—description of works.....	38
" Sarnia.....	100
Donald, Dr. J. T.—analysis of salt brines by 61, 62, 63, 64, 65, 66, 68, 69, 70, 71, 72, 73, 74, 78, 86.....	117
Duncan, Joseph: first to operate vacuum pan.....	

iii

E

	PAGE
Elarton Salt Co.—description of works	37
" Hyde Park Corner, Ont.	100
Electrolytic process for preparation of soda ash	133
Ells, Sydney C.—Notes on saline springs in N.W.T.	85
Elmwood: log of well drilled by Syndicate	78
Englehardt, Dr. F. E.—solar evaporation described	110
Evaporation methods	108
Exeter Salt Co.	100
" description of works	37

F

Fifth meridian: salt occurrences	89
Firebag river: salt springs	89
Fletcher, Hugh: quoted re Antigonish saline springs	17
Flow sheet: Canadian Salt Co.'s plant, Windsor, Ont.	40
" " chemical branch, Sandwich	42
" Dominion Salt Co.'s plant, Sarnia	38
" method of salt recovery	102
" Western Salt Co.'s plant, Mooretown	39
Fort McKay Oil and Asphalt Co.—saline water struck by	85
Fossil remains: few if any found in salt formations	12
Freezing or congelation concentration	107

G

Gibb electrolytic cell	43
Gladstone, Man.—saline waters in wells	73
Glaubers salts: See Sodium sulphate	134
Goderich Petroleum Co.	30
" Salt Co.	31
" well, log, analysis, etc.	31
Goesmann, Dr.—experiments by	111
Government well, Neepawa	76
Grabau: opinion of origin of salt in Salina formation	29
Graduation method of concentration of brine	106
Grainer system	116
Great Bear river salt springs	89
" Salt lake, Utah, source for production of salt	103
Grey, Young and Sparling Co. of Ont.—description of plant	35
" " " " Wingham	100

II

Halite: See Salt	
Hargreave and Bird process for manufacture of sodium carbonate	133
" process for manufacture of sodium sulphate	134
Harris, G. D.—originator of dome theory origin of salt	13
Hawley's salt block, Goderich	32
Hendricks, Geo. N.—salt manufacture at Sussex, N.B.	19
Hind, Prof. H. Y.—salt springs of Manitoba visited by	51
History of salt industry of Ontario	30
Hoffman, C.—analysis of Whycocomagh brine	16
How, Dr. Henry: spring at Salt Springs, N.S.	18
" " " Walton, N.S.	18
Hudson Bay Co.—manufacture of salt in Manitoba for	51
" " salt manufacture at Nanaimo	92
" " supply of salt from Salt river springs	88

	PAGE
Hunt, Dr. T. Sterry: analysis Goderich well.....	31
" " record of Goderich well.....	30
" " summary of diamond drill bore by H. Attrill.....	23
Huron salt block, Goderich.....	32
Hutchings, E. F.—log of well on farm of.....	77
Hydrochloric acid.....	135

I

Inniskillen salt block, Goderich.....	32
International salt block, Goderich.....	32
Introductory.....	1
Iodine.....	56
" in Manitoba brines.....	79

K

Kainite.....	7
Kettle process of artificial heat evaporation.....	114
Kieserite.....	7
Kwinitsa, B.C.—saline spring and rock salt at.....	91

L

La Saline: saline springs at.....	85
Lane: opinion of origin of salt in Salina formation.....	29
Le Blanc process for manufacture of soda.....	132
" salt cake.....	134
Liard river: " salt spring on Nohhanni butte.....	89
Lithium.....	56, 57, 58, 59
Logs of wells: Clinton.....	24
Elmwood.....	78
Goderich.....	31
Kincardine.....	24
McMurray, Alberta.....	84
Petrolia.....	24
Sarnia.....	25
Windsor, Ont.....	26
Winnipeg.....	77

M

McBride, James: well on farm of.....	74
McConnell, R. G.—Notes on saline springs of Salt river.....	87
" saline lakes, Cypress hills.....	90
" " spring, Liard river.....	89
" " " Red Earth creek.....	88
" " " Tar island.....	88
McKay, Mr.—manufacture of salt in Manitoba.....	52
McMurray: drilling operations at.....	83
McPherson, Mr.—salt spring on Liard river.....	89
Mackenzie River basin: salt springs.....	83, 86, 89
Maiden creek, B.C.—saline springs.....	92
Maitland salt block, Goderich.....	32
Manitoba: saline springs described.....	53
" salt in.....	49
" theories of origin of salt brines.....	49
Mantius crystallizing evaporator.....	122
Men employed in salt industry.....	95
Merrill, G. P.—solar evaporation described.....	108
Mineral water springs.....	74

V

Moberly, F. H.—operations at Kwinitsa.....	PAGE 91
Monkman, James: early manufacture of salt in Manitoba.....	51, 72
Mossy river: saline springs.....	55

N

Nahanni Butte: salt spring on.....	89
Nanaimo: salt spring.....	92
Neepawa: government well at.....	76
New Brunswick: brine springs in.....	18
no production of salt in.....	18
North American Chemical Co.	100
description of works.....	36
Northern Alberta Exploration Co.—drilling operations.....	83, 85
Northwest territories: salt occurrences in.....	83
Nova Scotia: no production of salt in.....	15
Salt Works and Exploration Co.....	17

O

Ochsenius, Dr. C.—evaporation theory reconstructed by.....	10
Ontario: boundaries of salt district.....	21
centre of salt industry of Canada.....	21
only salt deposits in Canada being exploited.....	1
People's Salt and Soda Co.....	100
" " description of plant.....	34
" " log of well.....	24
salt block, "Goderich".....	32
salt in.....	21
twelve plants in operation.....	34

P

Pan process of artificial heat evaporation.....	114
Parkhill Salt Co.....	100
description of works.....	37
Pelican bay: analysis of saline water from.....	56
Pick evaporator.....	127
Platt, Samuel: early drilling operations at Goderich.....	30
Platt's salt block, Goderich.....	32
Ponton, A. W.—saline creeks on 5th meridian.....	89
Prince Rupert: rock salt found near.....	91
Prince salt block, Goderich.....	32

Q

Quebec: mineral springs unfit for manufacture of salt.....	20
--	----

R

Ransford, J.—operator: North American Chemical Co.....	36
Stapleton salt works.....	35
Red Earth creek: saline spring.....	88
Red salt plant near Westbourne.....	75
Richardson, Sir J.—notes on saline springs of Salt river.....	86
" " saline spring, Liard river.....	89
" " Nanaimo.....	92
Robb, Chas.—quoted re Whycocomagh brine springs.....	16

Rock salt: see Salt.	PAGE
" associated with salt.	7
" commercial salt obtained from.	103
" mining of.	104
Rumball and Co., Geo.—first salt marketed by.	30

S

Salina formation, Ontario: salt beds in.	28
" thickness of.	29
Salina, Salt Spring creek: brine springs at.	19
Saline Spring A, Manitoba: particulars of.	60
" B,	62
" C,	63
" CC,	65
" D,	66
" E,	67
" F,	67
" G,	68
" H,	69
" I,	70
" J,	71
" well K	73
" L	74
" Spring M	74
Saline springs of Manitoba.	53
Salt beds of Ontario: extent and thickness.	21
" geology.	28
" origin.	29
" of rock salt common.	4
" blow pipe analysis.	4
" brines in N.S. associated with gypsum.	15, 17
" of Manitoba: history.	51
" origin.	49
" cake: see Sodium sulphate.	3
" chemical composition.	103
" commercial: two sources in nature.	55
" creek, saline springs.	4
" crystal forms of.	13
" dome theory of origin.	10
" evaporation: theory of origin.	97
" exports and imports.	119
" filter or barometric leg.	33
" first shipment to Winnipeg.	31
" well, Goderich: purity of.	30
" industry of Ontario, history.	33
" improvement in plant.	95
" men employed.	33
" met by keen opposition.	1
" possibilities in western provinces.	95
" wages paid.	108
" manufacture: evaporation methods.	100
" list of operators.	101
" technology.	79
" in Manitoba, conditions affecting.	14
" natural brines: theory of origin.	91
" occurrences in British Columbia.	15
" in Nova Scotia.	

	PAGE
Salt: occurrences in Saskatchewan, Alberta, and Northwest territories	83
" origin: theories of	9
" other salts associated with	6
" physical properties	3
" point: saline springs	56, 97
" preparation of for market	129
" production: statistics	93
" rock: no beds of known in Manitoba	49
" special uses of	130
" volcanic theory of origin	9
Salt river, Mackenzie basin: saline springs	86
Salt Springs, N.S.—salt spring at	18
Sanborn evaporator	127
Saskatchewan: salt occurrences in	83
Scale: difficulty from formation of	119
Sea water: recovery of salt from decreasing	103
Seaforth Syndicate	32
Seaforth: works established at	32
Sherzer: opinion of origin of salt in Salina formation	29
Shoal river: salt springs	59
Skeena river: rock salt found on	91
Smith, Tom, Gladstone, Man.—saline well on farm of	73
Soda products: duties on	96
" imports	96
Sodium carbonate	131
" purposes for which used	134
" chloride: see Salt	
" hydrate: methods of manufacture	135
" sulphate	134
Solar concentration	106, 108, 109, 110
" evaporation: different phases illustrated	113
possibilities of in Manitoba	81
" salt "aprons"	112
Solvay process: preparation of soda ash	132
Spencer, T. W.—account of salt manf. in Manitoba	52
" analysis of Manitoba brines	53
Springhill, N.S.—brine at	17
Stapleton salt works	100
" description of plant	35
" log of well	24
Statistics of Canadian salt production	93
Steam evaporation	116
Steepprock river	58
Sussex, N.B.—salt springs near	19
Swan river: salt spring	59
Swenson evaporator	120
Syracuse, N.Y.—manufacture of solar salt at	110

T

Table	I.	Distribution of rock salt and brines	5
"	II.	Thickness of beds and depth at which salt found, Ontario salt basin	26
"	III.	Analyses eight samples brines	48
"	IV.	Winnipegosis district: brine springs	72
"	V.	saline springs, data, etc.	72
"	VI.	Rain and snowfall at Swan river, Man.	80
"	VII.	" " Dauphin, Man.	80

	PAGE
Table VIII. Mean temperature at Swan river, Man.....	80
IX. Dauphin, Man.....	80
" X. Salt prices, Winnipeg and Ft. William or Port Arthur....	81
" XI. Production of salt in foreign countries.....	94
" XII. Detailed statistics of production 1908-1913.....	95
" XIII. Annual production 1886-1913.....	95
" XIV. Imports of soda products into Canada.....	96
" XV. Exports of salt.....	98
" XVI. Imports: salt paying duty.....	98
" XVII. " " not paying duty.....	99
" XVIII. Consumption of salt in Canada in 1912 and 1913.....	99
" XIX. Brecht's standard evaporator.....	127
Talmage, Dr. J. E.—solar evaporation described.....	109
Tar island, Peace river: saline spring.....	88
Technology of salt manufacture.....	101
Tecumseh salt block, Goderich.....	32
Tobique river, N.B., brine springs at.....	20
Tyrrell, J.B.—origin of salt brines of Manitoba.....	49
" salt springs of Manitoba visited by.....	53, 54, 57, 58, 59, 63, 67, 69, 71
V	
Vacuum pan evaporation.....	117
Victoria salt block, Goderich.....	32
Volcanic theory of origin of salt.....	9
W	
Wages paid in salt industry.....	95
Wait, F. G.—analysis of salt brines by.....	47, 57, 58, 59, 62, 64, 67, 69, 72, 86
Wallace, Dr. R. C.—examination of saline springs and gypsum deposits in Manitoba.....	50
Walther: theory to account for thick deposits.....	12
Walton, N.S.—brine spring at.....	18
Well K, Manitoba: particulars of.....	73
" L " " ".....	74
" O " " ".....	76
Well records.....	22
Westbourne district: saline springs of.....	73
" saline spring M.....	74
Western Canada Flour Mills Co.—description of salt works.....	36
" salt operators.....	100
" Salt Co.: description of works.....	39
" Mooretown.....	100
Whiteford, D.—operations at Kwinita.....	91
Whycocomagh: brine springs at.....	16
Wind concentration.....	106
Windsor, Ont.—well log.....	26
Winnipeg district: wells drilled in.....	76
" Mineral Springs Sanitarium.....	78
Winnipegosis district: saline springs of.....	54
Z	
Zaremba Co.—manufacturers of Mantius evaporator.....	122

CANADA
DEPARTMENT OF MINES
HON. LOUIS CODERRE, MINISTER; R. W. BROCK, DEPUTY MINISTER.
MINES BRANCH
EUGÈNE HAANEL, PH. D., DIRECTOR.

REPORTS AND MAPS

PUBLISHED BY THE
MINES BRANCH

REPORTS.

1. Mining Conditions in the Klondike, Yukon. Report on—by Eugène Haanel, Ph. D., 1902.
- †2. Great Landslide at Frank, Alta. Report on—by R. G. McConne B.A., and R. W. Brock, M.A., 1903.
- †3. Investigation of the different electro-thermic processes for the smelting of iron ores, and the making of steel, in operation in Europe. Report of Special Commission—by Eugene Haanel, Ph.D., 1904.
- †4. Rapport de la Commission nommée pour étudier les divers procédés électro-thermiques pour la réduction des minerais de fer et la fabrication de l'acier employés en Europe—by Eugene Haanel, Ph.D. (French Edition), 1905.
5. On the location and examination of magnetic ore deposits by magnetometric measurements—by Eugene Haanel, Ph.D., 1904.
- †7. Limestones and the Lime Industry of Manitoba. Preliminary Report on—by J. W. Wells, M.A., 1905.
- †8. Clays and Shales of Manitoba: Their Industrial Value. Preliminary Report on—by J. W. Wells, M.A., 1905.
- †9. Hydraulic Cements (Raw Materials) in Manitoba: Manufacture and Uses of. Preliminary Report on—by J. W. Wells, M.A., 1905.

†Publications marked thus † are out of print.

- †10. Mica: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (See No. 118.)
- †11. Asbestos: Its Occurrence, Exploitation, and Uses—by Fritz Cirkel, M.E., 1905. (See No. 69.)
- †12. Zinc Resources of British Columbia, and the Conditions affecting their Exploitation. Report of the Commission appointed to investigate—by W. R. Ingalls, M.E., 1905.
- †16. *Experiments made at Sault Ste. Marie, under Government auspices, in the smelting of Canadian iron ores by the electro-thermic process. Final Report on—by Eugene Haanel, Ph.D., 1907.
- †17. Mines of the Silver-Cobalt Ores of the Cobalt district: Their Present and Prospective Output. Report on—by Eugene Haanel, Ph.D., 1907.
- †18. Graphite: Its Properties, Occurrence, Refining, and Uses—by Fritz Cirkel, M.E., 1907.
- †19. Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nystrom, M.E., 1908.
- †20. Iron Ore Deposits of Nova Scotia. Report on (Part 1)—by J. E. Woodman, D.Sc.
- †21. Summary Report of Mines Branch, 1907-8.
- 22. Iron Ore Deposits of Thunder Bay and Rainy River districts. Report on—by F. Hille, M.E.
- †23. Iron Ore Deposits along the Ottawa (Quebec side), and Gatineau rivers. Report on—by Fritz Cirkel, M.E.
- 24. General Report on the Mining and Metallurgical Industries of Canada, 1907-8.
- 25. The Tungsten Ores of Canada. Report on—by T. L. Walker, Ph.D.
- 26. The Mineral Production of Canada, 1906. Annual Report on—by John McLeish, B.A.
- 26a. French Translation: The Mineral Production of Canada, 1906. Annual¹ Report on—by John McLeish, B.A.

*A few copies of the Preliminary Report 1906, are still available.

¹Publications marked thus † are out of print.

27. The Mineral Production of Canada, 1907. Preliminary Report on—by John McLeish, B.A.
- †27a. The Mineral Production of Canada, 1908. Preliminary Report on—by John McLeish, B.A.
- †28. Summary Report of Mines Branch, 1908.
- †28a. French translation: Summary Report of Mines Branch, 1908.
29. Chrome Iron Ore Deposits of the Eastern Townships. Monograph on—by Fritz Cirkel, M.E. (Supplementary Section: Experiments with Chromite at McGill University—by J. B. Porter, E.M., D.Sc.
30. Investigation of the Peat Bogs and Peat Fuel Industry of Canada, 1908. Bulletin No. 1—by Erik Nystrom, M.E., and A. Anrep, Peat Expert.
32. Investigation of Electric Shaft Furnace, Sweden. Report on—by Eugene Haanel, Ph.D.
47. Iron Ore Deposits of Vancouver and Texada Islands. Report on—by Einar Lindeman, M.E.
- †55. Report on the Bituminous, or Oil-shales of New Brunswick and Nova Scotia; also on the Oil-shale industry of Scotland—by R. W. Ells, LL.D.
56. French translation: Bituminous or Oil-shales of New Brunswick and Nova Scotia: also on the Oil-shale Industry of Scotland. Report on—by R. W. Ells, LL.D.
58. The Mineral Production of Canada, 1907 and 1908. Annual Report on—by John McLeish, B.A.

NOTE.—The following parts were separately printed and issued in advance of the Annual Report for 1907-8:—

- †31. Production of Cement in Canada, 1908.
42. Production of Iron and Steel in Canada during the Calendar Years 1907 and 1908.
43. Production of Chromite in Canada during the Calendar Years 1907 and 1908.

†Publications marked thus † are out of print

44. Production of Asbestos in Canada during the Calendar Years 1907 and 1908.
 - †45. Production of Coal, Coke, and Peat in Canada during the Calendar Years 1907 and 1908.
 46. Production of Natural Gas and Petroleum in Canada during the Calendar Years 1907 and 1908.
-
59. Chemical Analyses of Special Economic Importance made in the Laboratories of the Department of Mines, 1906-7-8. Report on—by F. G. Wait, M.A., F.C.S. (With Appendix on the Commercial Methods and Apparatus for the Analyses of Oil Shales—by H. A. Leverin, Ch. E.)
Schedule of Charges for Chemical Analyses and Assays.
 - †62. Mineral Production of Canada, 1909. Preliminary Report on—by John McLeish, B.A.
 63. Summary Report of Mines Branch, 1909.
 67. Iron Ore Deposits of the Bristol Mine, Pontiac county, Quebec. Bulletin No. 2—by Einar Lindeman, M.E., and Geo. C. Mackenzie, B.Sc.
 - †68. Recent Advance in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.
 69. Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Reports on—by Fritz Cirkel, M.E. (Second Edition, enlarged.)
 - †71. Investigation of the Peat Bogs and Peat Industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's Paper on Dr. M. Ekenberg's Wet-Carbonizing Process; from *Teknisk Tidskrift*, No. 12, December 26, 1908—translation by Mr. A. v. Anrep, Jr.; also a translation of Lieut. Ekelund's Pamphlet entitled 'A Solution of the Peat Problem', 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch. E. Bulletin No. 4—by A. v. Anrep (Second Edition, enlarged.)
 81. French Translation: Chrysotile-Asbestos: Its Occurrence, Exploitation, Milling, and Uses. Report on—by Fritz Cirkel, M.E.
 82. Magnetic Concentration Experiments. Bulletin No. 5—by Geo. C. Mackenzie, B.Sc.

†Publications marked thus † are out of print.

83. An investigation of the Coals of Canada with reference to their Economic Qualities as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E. M., D.Sc., R. J. Durley, Ma.E., and others—
 Vol. I—Coal Washing and Coking Tests.
 Vol. II—Boiler and Gas Producer Tests.
 Vol. III—
 Appendix I
 Coal Washing Tests and Diagrams.
 Vol. IV—
 Appendix II
 Boiler Tests and Diagrams.
 Vol. V—
 Appendix III
 Producer Tests and Diagrams.
 Vol. VI—
 Appendix IV
 Coking Tests.
 Appendix V
 Chemical Tests.
- †84. Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen Islands. Report on—by W. F. Jennison, M.E. (See No. 245.)
88. The Mineral Production of Canada, 1909. Annual Report on—by John McLeish, B.A.
- NOTE.—The following parts were separately printed and issued in advance of the Annual Report for 1909.*
- †79. Production of Iron and Steel in Canada during the Calendar Year, 1909.
- †80. Production of Coal and Coke in Canada during the Calendar Year, 1909.
85. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials during the Calendar Year, 1909.
89. Reprint of Presidential address delivered before the American Peat Society at Ottawa, July 25, 1910. By Eugene Haanel, Ph.D.
90. Proceedings of Conference on Explosives.
92. Investigation of the Explosives Industry in the Dominion of Canada, 1910. Report on—by Capt. Arthur Desborough. (Second Edition.)

†Publications marked thus † are out of print.

93. Molybdenum Ores of Canada. Report on—by Professor T. L. Walker, Ph. D.
100. The Building and Ornamental Stones of Canada. Report on—by Professor W. A. Parks, Ph. D.
- 100a. French Translation: The Building and Ornamental Stones of Canada. Report on—by W. A. Parks.
102. Mineral Production of Canada, 1910. Preliminary Report on—by John McLeish, B.A.
- †103. Summary Report of Mines Branch, 1910.
104. Catalogue of Publications of Mines Branch, from 1902 to 1911; containing Tables of Contents and list of Maps, etc.
105. Austin Brook Iron-bearing district, Report on—by E. Lindeman, M.E.
110. Western Portion of Torbrook Iron Ore Deposits, Annapolis county, N.S. Bulletin No. 7—by Howells Fréchette, M.Sc.
111. Diamond Drilling at Point Mamainse, Ont. Bulletin No. 6—by A. C. Lane, Ph.D., with Introductory by A. W. G. Wilson, Ph.D.
118. Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid, M.E.
142. Summary Report of Mines Branch, 1911.
143. The Mineral Production of Canada, 1910. Annual Report on—by John McLeish, B.A.

NOTE.—The following parts were separately printed and issued in advance of the Annual Report for 1910.

- †114. Production of Cement, Lime, Clay Products, Stone and other Structural Materials in Canada, 1910.
- †115. Production of Iron and Steel in Canada during the Calendar Year 1910.
- †116. Production of Coal and Coke in Canada during the Calendar Year 1910.

†Publications marked thus † are out of print.

- †117. General Summary of the Mineral Production of Canada during the Calendar Year 1910.
145. Magnetic Iron Sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.
149. French translation: Magnetic Iron Sands of Natashkwan, Saguenay county, Que. Report on—by Geo. C. Mackenzie, B.Sc.
- †150. The Mineral Production of Canada, 1911. Preliminary Report on—by John McLeish, B.A.
151. Investigation of the Peat Bogs and Peat Industry of Canada, 1910-1911 Bulletin No. 8—by A. v. Anrep, Peat Expert.
154. The Utilization of Peat Fuel for the Production of Power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-11. Report on—by B. F. Haanel, B.Sc.
155. French translation: The Utilization of Peat Fuel for the Production of Power, being a record of experiments conducted at the Fuel Testing Station, Ottawa, 1910-11. Report on—by B. F. Haanel, B.Sc.
156. French translation: The Tungsten Ores of Canada. Report on—T. L. Walker, Ph.D.
167. Pyrites in Canada: Its Occurrence, Exploitation, Dressing, and Uses. Report on—by A. W. G. Wilson, Ph.D.
169. French translation: Pyrites in Canada: Its Occurrence, Exploitation, Dressing, and Uses. Report on—by A. W. G. Wilson, Ph.D.
170. The Nickel Industry: with Special Reference to the Sudbury region, Ont. Report on—by Professor A. P. Coleman, Ph.D.
180. French translation: Investigation of the Peat Bogs, and Peat Industry of Canada, 1910-11. Bulletin No. 8—by A. v. Anrep, Peat Expert.
184. Magnetite Occurrences along the Central Ontario Railway. Report on—by E. Lindeman.
195. French translation: Magnetite Occurrences along the Central Ontario Railway. Report on—by E. Lindeman, M.E.

†Publications marked thus † are out of print.

196. French translation: Investigation of the Peat Bogs and Peat Industry of Canada, 1909-10; to which is appended Mr. Alf. Larson's paper on Dr. Ekenburg's Wet Carbonizing Process: from Teknisk Tidsskrift, No. 12, December 26, 1908—translation by Mr. A. v. Anrep; also translation of Lieut. Ekelund's Pamphlet entitled "A solution of the Peat Problem," 1909, describing the Ekelund Process for the Manufacture of Peat Powder, by Harold A. Leverin, Ch.E. Bulletin No. 4—by A. v. Anrep, Peat Expert. (Second Edition, enlarged.)
197. French translation: Molybdenum Ores of Canada. Report on—by Professor T. L. Walker, Ph.D.
198. French translation: Peat and Lignite: Their Manufacture and Uses in Europe—by Erik Nystrom, M.E., 1908.
201. The Mineral Production of Canada during the Calendar Year 1911. Annual Report on—by John McLeish, B.A.

NOTE.—The following parts were separately printed and issued in advance of the Annual Report for 1911.

181. Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada during the Calendar Year 1911. Bulletin on—by John McLeish, B.A.
- †182. Production of Iron and Steel in Canada during the Calendar Year 1911. Bulletin on—by John McLeish, B.A.
183. General Summary of the Mineral Production in Canada during the Calendar Year 1911. Bulletin on—by John McLeish, B.A.
- †199. Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals of Canada, during the Calendar Year 1911. Bulletin on—by C. T. Cartwright, B.Sc.
- †200. The Production of Coal and Coke in Canada during the Calendar Year 1911. Bulletin on—by John McLeish, B.A.
202. French translation: Graphite: Its Properties, Occurrence, Refining, and Uses—by Fritz Cirkel, M.E., 1907.
203. Building Stones of Canada—Vol. II: Building and Ornamental Stones of the Maritime Provinces. Report on—by Professor W. A. Parks, Ph.D.
209. The Copper Smelting Industry of Canada. Report on—by A. W. G. Wilson, Ph.D.

†Publications marked thus † are out of print.

- 216. Mineral Production of Canada, 1912. Preliminary Report on—by John McLeish, B.A.
- 219. French translation: Austin Brook Iron-bearing district. Report on—by E. Lindeman, M.E.
- 222. Lode Mining in Yukon: An investigation of the Quartz Deposits of the Klondike Division. Report on—by T. A. MacLean, B.Sc.
- 224. Summary Report of the Mines Branch, 1912.
- 226. French translation: Chrome Iron Ore Deposits of the Eastern Townships. Monograph on—by Fritz Cirkel, M.E. (Supplementary Section: Experiments with Chromite at McGill University—by Professor J. B. Porter, E.M., D.Sc.)
- 227. Sections of the Sydney Coal Field—by J. G. S. Hudson.
- †229. Summary Report of the Petroleum and Natural Gas Resources of Canada, 1912—by F. G. Clapp, A.M. See. No. 224.)
- 230. Economic Minerals and the Mining Industries of Canada.
- 231. French translation: Economic Minerals and the Mining Industries of Canada.
- 233. French translation: Gypsum Deposits of the Maritime Provinces of Canada—including the Magdalen Islands. Report on—by W. F. Jennison, M.E.
- 245. Gypsum in Canada: Its Occurrence, Exploitation, and Technology. Report on—by L. H. Cole, B.Sc.
- 254. Calabogie Iron-Bearing District. Report on—by E. Lindeman, M.E.
- 259. Preparation of Metallic Cobalt by Reduction of the Oxide. Report on—by Professor H. T. Kalmus, B.Sc., Ph.D.
- 262. The Mineral Production of Canada during the Calendar Year 1912. Annual Report on—by John McLeish, B.A.

NOTE.—The following parts were separately printed and issued in advance of the Annual Report for 1912.

- 238. General Summary of the Mineral Production of Canada, during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.

- †247. Production of Iron and Steel in Canada during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.

†Publications marked thus † are out of print.

- †256. Production of Copper, Gold, Lead Nickel, Silver, Zinc, and other Metals of Canada, during the Calendar Year 1912 —by C. T. Cartwright, B.Sc.
- 257. Production of Cement, Clay Products, stone, and other Structural Materials during the Calendar Year 1912. Report on—by John McLeish, B.A.
- †258. Production of Coal and Coke in Canada, during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.

- 263. French translation: Recent Advances in the Construction of Electric Furnaces for the Production of Pig Iron, Steel, and Zinc. Bulletin No. 3—by Eugene Haanel, Ph.D.
- 264. French translation: Mica: Its Occurrence, Exploitation, and Uses. Report on—by Hugh S. de Schmid, M.E.
- 265. French translation: Annual Mineral Production of Canada, 1911. Report on—by John McLeish, B.A.
- 266. Investigation of the Peat Bogs and Peat Industry of Canada, 1911 and 1912. Bulletin No. 9—by A. v. Anrep, Peat Expert.
- 279. Building and Ornamental Stones of Canada—Vol. III. Report on—by Professor W. A. Parks, Ph.D.
- 281. The Bituminous Sands of Northern Alberta. Report on—by S. C. Ells, M.E.
- 283. Mineral Production of Canada, 1913. Preliminary report on—by J. McLeish, B.A.
- 288. French translation: Production of Coal and Coke in Canada during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.
- 290. French translation: Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and Other Metals of Canada, during the Calendar Year 1912. Bulletin on—by C. T. Cartwright, B.Sc.
- 299. Peat, Lignite, and Coal: Their Value as Fuels for the Production of Gas and Power in the By-product Recovery Producer. Report on —by B. F. Haanel, B.Sc.
- 303. Moose Mountain Iron-Bearing District. Report on—by E. Lindeman, M.E.
- 305. Non-metallic minerals used in the Canadian Manufacturing Industries. Report on—by H. Frechette, M.Sc.

—†Publications marked thus † are out of print.

- 309. The Physical Properties of the Metal Cobalt, Part II. Report on—by H. T. Kalmus, B.Sc., Ph.D.
- 315. The Production of Iron and Steel during the Calendar Year 1913. Bulletin on—by John McLeish, B.A.
- 316. The Production of Coal and Coke during the Calendar Year 1913. Bulletin on—by John McLeish, B.A.
- 317. The Production of Copper, Gold, Lead, Nickel, Silver, Zinc, and other Metals, during the Calendar Year 1913. Bulletin on—by C. T. Cartwright, B.Sc.
- 318. The Production of Cement, Lime, Clay Products, Stone, and other Structural Materials in Canada, during the Calendar Year, 1913. By J. McLeish, B.A.
- 319. A General Summary of the Mineral Production in Canada during the Calendar Year 1913. Bulletin on—by J. McLeish, B.A.
- 320. The Mineral Production of Canada, 1913. Annual Report on—by John McLeish, B.A.
- 322. Economic Minerals and Mining Industries of Canada. (Revised Edition, for Panama-Pacific Exposition.)
- 325. The Salt Deposits of Canada, and the Salt Industry. Report on—by L. Heber Cole, B.Sc.

NOTE.—The Division of Mineral Resources and Statistics has prepared the following lists of mine, smelter, and quarry operators: Metal mines and smelters, Coal mines, Stone quarry operators, Manufacturers of clay products and Manufacturers of lime; copies of the lists may be obtained on application.

IN THE PRESS.

- 179. French translation: The Nickel Industry: with Special Reference to the Sudbury region. Report on—by Prof. A. P. Coleman, Ph.D.
- 204. French translation: Building Stones of Canada—Vol. II: Building and Ornamental Stones of the Maritime Provinces. Report on—by W. A. Parks, Ph.D.
- 285. Summary Report of Mines Branch, 1913.
- 287. French translation: Production of Iron and Steel in Canada during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.
- 289. French translation: Production of Cement, Lime, Clay Products, Stone, and Other Structural Materials during the Calendar Year 1912. Bulletin on—by John McLeish, B.A.

291. Petroleum and Natural Gas Resources of Canada. Report on—by F. G. Clapp, A.M., and others.
308. French translation: An investigation of the Coals of Canada with reference to their Economic Qualities: as conducted at McGill University under the authority of the Dominion Government. Report on—by J. B. Porter, E.M., D.Sc., R. J. Durling, M.A.E., and others
- Vol. I—Coal Washing and Coking Tests.
Vol. II—Boiler and Gas Producer Tests.
Vol. III—
Appendix I
Coal Washing Tests and Diagrams.
Vol. IV—
Appendix II
Boiler Tests and Diagrams.
314. French translation: Iron Ore Deposits, Bristol Mine, Pontiac county, Quebec. Report on—by E. Lindeman, M.E.
331. The Investigation of Five Samples of Alberta Lignites. Report on—by B. F. Haanel, B.Sc.

MAPS.

- †6. Magnetometric Survey, Vertical Intensity: Calabogie Mine, Bagot township, Renfrew county, Ontario—by E. Nystrom, 1904. Scale 60 feet to 1 inch. Summary report, 1905. (See Map No. 249.)
- †13. Magnetometric Survey of the Belmont Iron Mines, Belmont township, Peterborough county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1905. (See Map. No. 186).
- †14. Magnetometric Survey of the Wilbur Mine, Lavant township, Lanark county, Ontario—by B. F. Haanel, 1905. Scale 60 feet to 1 inch. Summary report, 1905.
- †33. Magnetometric Survey, Vertical Intensity: Lot 1, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch.
- †34. Magnetometric Survey, Vertical Intensity: Lots 2 and 3, Concession VI, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch.

NOTE.—1. Maps marked thus * are to be found only in reports.
2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †35. Magnetometric Survey, Vertical Intensity: Lots 10, 11, and 12, Concession IX, and Lots 11 and 12, Concession VIII, Mayo township, Hastings county, Ontario—by Howells Fréchette, 1909. Scale 60 feet to 1 inch.
- *36. Survey of Mer Bleue Peat Bog, Gloucester township, Carleton county, and Cumberland township, Russell county, Ontario—by Erik Nystrom, and A. v. Anrep. (Accompanying report No. 30.)
- *37. Survey of Alfred Peat Bog, Alfred and Caledonia townships, Prescott county, Ontario—by Erik Nystrom, and A. v. Anrep. (Accompanying report No. 30.)
- *38. Survey of Welland Peat Bog, Wainfleet and Humberstone townships, Welland county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)
- *39. Survey of Newington Peat Bog, Osnabruck, Roxborough, and Cornwall townships, Stormont county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)
- *40. Survey of Perth Peat Bog, Drummond township, Lanark county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)
- *41. Survey of Victoria Road Peat Bog, Bexley and Carden townships, Victoria county, Ontario—by Erik Nystrom and A. v. Anrep. (Accompanying report No. 30.)
- *48. Magnetometric Survey of Iron Crown claim at Nimpkish (Klaanch) river, Vancouver island, B.C.—by E. Lindeman. Scale 60 feet to 1 inch. (Accompanying report No. 47.)
- *49. Magnetometric Survey of Western Steel Iron claim, at Sechart, Vancouver Island, B.C.—by E. Lindeman. Scale 60 feet to 1 inch (Accompanying report No. 47.)
- *53. Iron Ore Occurrences, Ottawa and Pontiac counties, Quebec, 1908—by J. White and Fritz Cirkel. (Accompanying report No. 23.)
- *54. Iron Ore Occurrences, Argenteuil county, Quebec, 1908—by Fritz Cirkel. (Accompanying report No. 23.) Out of print.
- 55. The Productive Chrome Iron Ore District of Quebec—by Fritz Cirkel. (Accompanying report No. 29.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †60. Magnetometric Survey of the Bristol Mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet to 1 inch. (Accompanying report No. 67.)
- †61. Topographical Map of Bristol Mine, Pontiac county, Quebec—by E. Lindeman. Scale 200 feet to 1 inch. (Accompanying report No. 67.)
- †64. Index Map of Nova Scotia: Gypsum—by W. F. Jennison. } (Accompanying report No. 84)
- †65. Index Map of New Brunswick: Gypsum—by W. F. Jennison } (Accompanying report No. 84)
- †66. Map of Magdalen Islands: Gypsum—by W. F. Jennison. }
- †70. Magnetometric Survey of Northeast Arm Iron Range, Lake Timagami, Nipissing district, Ontario—by E. Lindeman. Scale 200 feet = 1 inch. (Accompanying report No. 63.)
- †72. Brunner Peat Bog, Ontario—by A. v. Anrep.
- †73. Komoka Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No 71)
- †74. Brockville Peat Bog, Ontario—by A. v. Anrep.
- †75. Rondeau Peat Bog, Ontario—by A. v. Anrep. Out of print.
- †76. Alfred Peat Bog, Ontario—by A. v. Anrep.
- †77. Alfred Peat Bog, Ontario: Main Ditch profile—by A. v. Anrep.
- †78. Map of Asbestos Region, Province of Quebec, 1910—by Fritz Cirkel. Scale 1 mile to 1 inch. (Accompanying report No. 69.)
- †94. Map showing Cobalt, Gowganda, Shiningtree, and Porcupine districts—by L. H. Cole. (Accompanying Summary report, 1910.)
- †95. General Map of Canada, showing Coal Fields. (Accompanying report No. 83—by Dr. J. B. Porter.)
- †96. General Map of Coal Fields of Nova Scotia and New Brunswick. (Accompanying report No. 83—by Dr. J. B. Porter.)
- †97. General Map showing Coal Fields in Alberta, Saskatchewan, and Manitoba. (Accompanying report No. 83—by Dr. J. B. Porter.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †98. General Map of Coal Fields in British Columbia. (Accompanying report No. 83—by Dr. J. B. Porter.)
- †99. General Map of Coal Field in Yukon Territory. (Accompanying report No. 83—by Dr. J. B. Porter.)
- †106. Geological Map of Austin Brook Iron Bearing district, Bathurst township, Gloucester county, N.B.—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)
- †107. Magnetometric Survey, Vertical Intensity: Austin Brook Iron Bearing District—by E. Lindeman. Scale 400 feet to 1 inch. (Accompanying report No. 105.)
- †108. Index Map showing Iron Bearing Area at Austin Brook—by E. Lindeman. (Accompanying report No. 105.)
- *112. Sketch plan showing Geology of Point Maimaise, Ont.—by Professor A. C. Lane. Scale, 4,000 feet to 1 inch. (Accompanying report No. 111.)
- †113. Holland Peat Bog, Ontario—by A. v. Anrep. (Accompanying report No. 151.)
- *119-137. Mica: Township maps, Ontario and Quebec—by Hugh S. de Schmid. (Accompanying report No. 118.)
- †138. Mica: Showing Location of Principal Mines and Occurrences in the Quebec Mica Area—by Hugh S. de Schmid. Scale 3.95 miles to 1 inch. (Accompanying report No. 118.)
- †139. Mica: Showing Location of Principal Mines and Occurrences in the Ontario Mica Area—by Hugh S. de Schmid. Scale 3.95 miles to 1 inch. (Accompanying report No. 118.)
- †140. Mica: Showing Distribution of the Principal Mica Occurrences in the Dominion of Canada—by Hugh S. de Schmid. Scale 3.95 miles to 1 inch. (Accompanying report No. 118.)
- †141. Torbrook Iron Bearing District, Annapolis county, N.S.—by Howells Fréchette. Scale 400 feet to 1 inch. (Accompanying report No. 110.)
- †146. Distribution of Iron Ore Sands of the Iron Ore Deposits on the North Shore of the River and Gulf of St. Lawrence, Canada—by Geo. C. Mackenzie. Scale 100 miles to 1 inch. (Accompanying report No. 145.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †147. Magnetic Iron Sand Deposits in relation to Natashkwan harbour and Great Natashkwan river, Que. (Index Map)—by Geo. C. Mackenzie. Scale 40 chains to 1 inch. (Accompanying report No. 145.)
- †148. Natashkwan Magnetic Iron Sand Deposits, Saguenay county, Que.—by Geo. C. Mackenzie. Scale 1,000 feet to 1 inch. (Accompanying report No. 145.)
- †152. Map showing the Location of Peat Bogs investigated in Ontario—by A. v. Anrep.
- †153. Map Showing the Location of Peat Bogs investigated in Manitoba—by A. v. Anrep.
- †157. Lac du Bonnet Peat Bog, Manitoba—by A. v. Anrep.
- †158. Transmission Peat Bog, Manitoba—by A. v. Anrep.
- †159. Corduroy Peat Bog, Manitoba—by A. v. Anrep.
- †160. Boggy Creek Peat Bog, Manitoba—by A. v. Anrep.
- †161. Rice Lake Peat Bog, Manitoba—by A. v. Anrep.
- †162. Mud Lake Peat Bog, Manitoba—by A. v. Anrep.
- †163. Litter Peat Bog, Manitoba—by A. v. Anrep.
- †164. Julius Peat Litter Bog, Manitoba—by A. v. Anrep.
- †165. Fort Francis Peat Bog, Ontario—by A. v. Anrep.
- (Accompanying report No. 151)
- †166. Magnetometric Map of Mine No. 3, Lot 7, Concessions V and VI McKim township, Sudbury district, Ont.—by E. Lindeman. (Accompanying Summary Report, 1911.)
- †168. Map showing Pyrites Mines and Prospects in Eastern Canada, and their relation to the United States Market—by A. W. G. Wilson. Scale 125 miles to 1 inch. (Accompanying report No. 167.)
- †171. Geological Map of Sudbury Nickel region, Ont.—by Prof. A. P. Coleman. Scale 1 mile to 1 inch. (Accompanying report No. 170.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †172. Geological Map of Victoria mine—by Prof. A. P. Coleman.
- †173. Geological Map of Crean Hill mine—by Prof. A. P. Coleman.
- †174. Geological Map of Creighton mine—by Prof. A. P. Coleman.
- †175. Geological Map showing contact of Norite and Laurentian [in vicinity of Creighton mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)
- †176. " " of Copper Cliff offset—by Prof. A. P. Coleman. (Accompanying report No. 170.)
- †177. " " No. 3 Mine—by Prof. A. P. Coleman. (Accompanying report No. 170.)
- †178. " " showing vicinity of Stobie and No. 3 mines—by Prof. A. P. Coleman. (Accompanying report No. 170.)
- †185. Magnetometric Survey, Vertical Intensity: Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †185a. Geological Map, Blairton iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †186. Magnetometric Survey, Belmont iron mine, Belmont township, Peterborough county, Ont.—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †186a. Geological Map, Belmont iron mine, Belmont township, Peterborough county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †187. Magnetometric Survey, Vertical Intensity: St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †187a. Geological Map, St. Charles mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

NOTE.—1. Maps marked thus * are to be found only in reports.
 2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †188. Magnetometric Survey, Vertical Intensity: Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †188a. Geological Map, Baker mine, Tudor township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †189. Magnetometric Survey, Vertical Intensity: Ridge iron ore deposits, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †190. Magnetometric Survey, Vertical Intensity: Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †190a. Geological Map, Coehill and Jenkins mines, Wollaston township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †191. Magnetometric Survey, Vertical Intensity: Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †191a. Geological Map, Bessemer iron ore deposits, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †192. Magnetometric Survey, Vertical Intensity: Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †192a. Geological Map, Rankin, Childs, and Stevens mines, Mayo township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †193. Magnetometric Survey, Vertical Intensity: Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †193a. Geological Map, Kennedy property, Carlow township, Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †194. Magnetometric Survey, Vertical Intensity: Bow Lake iron ore occurrences, Faraday township. Hastings county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 184.)
- †204. Index Map, Magnetic occurrences along the Central Ontario Railway—by E. Lindeman, 1911. (Accompanying report No. 184.)
- †205. Magnetometric Map, Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman, 1911. (Accompanying report No. 303.)
- †205a. Geological Map, Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 1, 2, 3, 4, 5, 6, and 7—by E. Lindeman. (Accompanying report No. 303.)
- †206. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Northern part of Deposit No. 2—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)
- †207. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposits Nos. 8, 9, and 9A—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)
- †208. Magnetometric Survey of Moose Mountain iron-bearing district, Sudbury district, Ontario: Deposit No. 10—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)
- †208a. Magnetometric Survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: Eastern portion of Deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)
- †208b. Magnetometric Survey, Moose Mountain iron-bearing district, Sudbury district, Ontario: Western portion of Deposit No. 11—by E. Lindeman, 1912. Scale 200 feet to 1 inch. (Accompanying report No. 303.)
- †208c. General Geological Map, Moose Mountain iron-bearing district, Sudbury district, Ontario—by E. Lindeman, 1912. Scale, 800 feet to 1 inch. (Accompanying report No. 303.)
- †210. Location of Copper Smelters in Canada—by A. W. G. Wilson. Scale 197.3 miles to 1 inch. (Accompanying report No. 209.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †215. Province of Alberta: Showing properties from which samples of coal were taken for gas producer tests, Fuel Testing Division, Ottawa. (Accompanying Summary Report 1912.)
- †220. Mining Districts, Yukon. Scale 35 miles to 1 inch—by T. A. MacLean. (Accompanying report No. 222.)
- †221. Dawson Mining District, Yukon. Scale 2 miles to 1 inch—by T. A. MacLean. (Accompanying report No. 222.)
- *228. Index Map of the Sydney Coal Field, Cape Breton, N.S. (Accompanying report No. 227.)
- †232. Mineral Map of Canada. Scale 100 miles to 1 inch. (Accompanying report No. 230.)
- †239. Index Map of Canada, showing gypsum occurrences. (Accompanying report No. 245.)
- †240. Map showing Lower Carboniferous formation in which gypsum occurs. Scale 100 miles to 1 inch. (Accompanying report No. 245.)
- †241. Map showing relation of gypsum deposits in Northern Ontario to railway lines. Scale 100 miles to 1 inch. (Accompanying report No. 245.)
- †242. Map, Grand River gypsum deposits, Ontario. Scale 4 miles to 1 inch. (Accompanying report No. 245.)
- †243. Plan of Manitoba Gypsum Co.'s properties. (Accompanying report No. 245.)
- †244. Map showing relation of gypsum deposits in British Columbia to railway lines and market. Scales 35 miles to 1 inch. (Accompanying report No. 245.)
- †249. Magnetometric Survey, Caldwell and Campbell mines, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)
- †250. Magnetometric Survey, Black Bay or Williams mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

- †251. Magnetometric Survey, Bluff Point iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)
- †252. Magnetometric Survey, Culhane mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)
- †253. Magnetometric Survey, Martel or Wilson iron mine, Calabogie district, Renfrew county, Ontario—by E. Lindeman, 1911. Scale 200 feet to 1 inch. (Accompanying report No. 254.)
- †261. Magnetometric Survey, Northeast Arm iron range, Lot 339 E. T. W. Lake Timagami, Nipissing district, Ontario—by E. Nystrom, 1903. Scale 200 feet to 1 inch.
- †268. Map of Peat Bogs Investigated in Quebec—by A. v. Anrep, 1912.
- †269. Large Tea Field Peat Bog, Quebec " "
- †270. Small Tea Field Peat Bog, Quebec " "
- †271. Lanorie Peat Bog, Quebec " "
- †272. St. Hyacinthe Peat Bog, Quebec " "
- †273. Rivière du Loup Peat Bog " "
- †274. Cacouna Peat Bog " "
- †275. Le Parc Peat Bog, Quebec " "
- †276. St. Denis Peat Bog, Quebec " "
- †277. Rivière Ouelle Peat Bog, Quebec " "
- †278. Moose Mountain Peat Bog, Quebec " "
- †284. Map of northern portion of Alberta, showing position of outcrops of bituminous sand. Scale 12½ miles to 1 inch. (Accompanying report No. 281.)
- †293. Map of Dominion of Canada, showing the occurrences of oil, gas, and tar sands. Scale 197 miles to 1 inch. (Accompanying report No. 291.)

NOTE.—1. Maps marked thus * are to be found only in reports.

2. Maps marked thus † have been printed independently of reports, hence can be procured separately by applicants.

